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CENTER FOR FISHERIES ENGINEERING RESEARCH

Conference Proceedings:

Gear Selectivity as a Management Tool

edited by
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and
Thecla J. Ree

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ABSTRACT

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October 14-15, 1986

Clifford A. Goudey,
Kathryn E. Paterson, and
Thecla J. Ree, eds.

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This report, a collection of transcripts from a conference held at MIT, deals with the design and use of size- and species- specific gear that has the potential to improve utilization and management of fish stocks. Speakers representing commercial fishermen, agency personnel, and gear manufacturers focus on the viability of introducing gear that is more selective, problems of enforcement, and the effects of gear-specific regulations on fishermen, fishing practices, and gear manufacturers. Specific fisheries of the New England region are covered by category — groundfish, shrimp, scallops, and pelagics. The West and Gulf Coasts are represented by speakers who summarize their experiences with selectivity techniques in those regions. In all, the operational advantages associated with a resource-sparing design were identified as an important incentive towards its adoption.

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Introduction

Fisheries development and trawl gear research in the New England region are accomplished by a variety of local, state, and federal organizations. The projects undertaken by these groups differ in approach and scope but share at least two common threads: low levels of funding and low visibility. This reality is in contrast to the importance of the work and the crisis that the industry is now facing. Coordination of this fishering gear research has traditionally been on an ad hoc basis, with resources and results being shared informally.

A year ago, a meeting was held in Boothbay Harbor, Maine, to initiate a more formal mechanism for communication by these groups and individuals. Sponsored by the Maine Department of Marine Resources, a framework was established for future coordination and several areas of common interest and concern were identified.

This conference, held at the Massachusetts Institute of Technology, is a continuation of that process and, as the name implies, is an effort to show the design and use of more size- and species-selective gear can help in better utilization of our fish stocks. Does the introduction or even the requirement of more selective gear offer a real alternative to management officials? What has been the experience in other regions and countries with gear-specific regulations? How would such regulations affect fishermen, fishing practices, or gear manufacturers? These were the specific questions this conference set out to answer.

Speakers from the West Coast and the Gulf Coast were invited to share their perspectives with us. In addition, a summary of experiences, reported at the recent ICES meeting in Europe, were also presented. Specific fisheries of the New England region were covered, organized loosely under these topics: groundfish, shrimp, scallops, and pelagics. The results or progress reports of several projects were reported.

The practical limitations of many of the ideas covered dominated much of the discussions following each topic. In addition, a portion of the conference agenda dealt with the issue of how selective gear might be implemented in the net shop and aboard vessels. A nearly universal concern was expressed over the fact that without enforcement, gear restrictions, like any other regulations, would be ineffective. If, on the other hand, selective gear brought with it other more tangible benefits, it might be used willingly. The identification of any operational advantages associated with a resource-sparing design will be an important incentive towards its adoption.

The conference was concluded with presentations on the research plans of the participating organizations and discussions of opportunities for cooperation.

Acknowledgements

The preparations of these proceedings were supported by the MIT Sea Grant College Program under NOAA grants NA-86-AAD-SG089 and NA86EA-D-00049 and by the New England Fisheries Development Foundation.

The editors wish to thank the staff of the MIT Sea Grant Program, the MIT Audio Visual Services, and the MIT Food Services for their help during the conference. We also wish to thank the conference speakers for their efforts during the conference and afterwards in reviewing their individual transcripts. Though each speaker was invited, they all came representing their organizations and at their own expense. We especially appreciate the fishermen/speakers and the fishermen/attendees for whom participation in such shoreside activities typically means a tied-up boat and lost income.

Summary of Selectivity Techniques From ICES

Al Blott
NMFS Narragansett Laboratory

ICES is short for the International Council for Exploration of the Sea, the oldest international marine research organization in the world. It members are mostly Northern European and North American countries and it is made up of a variety of committees, each committee having its own speciality. The committee we are interested in is called the Fish Capture Committee. Within the Fish Capture Committee, is a group called the Working Group on Fishing Technology and Fish Behavior. This group usually meets once a year for two or three days in the spring, in a different country every year. Each represented country gives a progress report on what it has done since the previous year, and then will usually present papers are on one or two special topics. The idea behind ICES is that it promotes research within each of its member countries on issues that are of importance to all of them.

In addition, ICES provides this research information to management organizations in Northern Europe. At the working group meetings we usually have gear researchers from England, Scotland, Iceland, Norway, Sweden, Germany, Denmark, Holland, Belgium, France and Canada. Sometimes the United States, Italy, and the Soviet Union are represented.

In 1986, one of the special topics happened to be entitled "Engineering and Behavioral Aspects of the Selectivity of Fish Sampling Gears." There were a variety of papers presented on different selection techniques and related problems. They did not simply relate to sampling gear because a great deal of sampling gear has been adapted for commercial use. These papers are working papers which are based on the results of limited data; they usually need to be refined later on. Some of the curves that are drawn may not be exact, but it is the ideas behind them that are important. I am going to be talking about trawl gear because that was the major source of interest.

We will start with two subjects that we will cover in greater detail later on. The first subject is square mesh codends. Several member countries have been working on these codends over the last few years. Belgium did some studies on square mesh codends and beam trawls. They reported that their results were inconclusive due to low catch rates.

The Norwegians are also working on square mesh codends. They tested knotless netting in trouser trawls. What that means is two codends side by side on one trawl. In this case, one of the codends had knotless netting hung, whereas the other codend had the usual diamond shape. The first thing they found is that the knotless netting didn't work very well; it wasn't stable and the mesh size would increase. But they did find that the 50% retention point was higher with square mesh for cod and haddock. However, the overall length distributions were not significantly different. Of course, you can get an increase in 50% retention length just by increasing the mesh size of a diamond-shaped codend. They also found a lot of problems when they got into heavy amounts of redfish because they gilled up in the square meshes. I suspect we will have the same problem with dogfish if we use the square mesh.

The Norwegians were also testing square mesh codends on shrimp trawls. Their shrimp species are identical to those found in the Gulf of Maine. They found a reduction in the catch of undersized shrimp and a reduction in the catch of small cod of about 4 to 8 inch in length. This has always been a problem with their shrimp fisheries. The square mesh codend helped both of those, but again these results are the preliminary and have not been fully analyzed.

Of course, most of us know that Scotland started this latest round of square mesh research. The square mesh idea was actually first put forth by Scotland back in 1926 in a report to ICES. Scotland has also done most of the recent research, some of it in cooperation with the Netherlands. Their latest results show quite a variance in catch data. The Scots found the selection range for haddock to be smaller in the square mesh than in the diamond. According to our definition of selectivity, the square mesh is more selective. However, they did not find the same thing occurred with whiting and are not sure why this is. They suspect that it has something to do with the difference in the shapes of the fish: whiting is more needle or cigar shaped; therefore, it has the ability to get out of the diamond meshes as easily as it gets out of the square mesh.

Another factor for this disparity is that Scottish fisheries are in a very different condition from ours in the United States. The haddock they are talking about are mostly smaller than 14 inches long, or 35 cm. All of their mesh sizes are regulated mesh sizes and are much smaller than ours. They couldn't find any large haddock to test the larger mesh size codends. The Scots did find that for the same mesh size in square and in diamond, the 50% retention length was higher for the square mesh than for the diamond in both the haddock and the whiting fishes. That is not surprising, and,again, you can get the same effect by using a larger diamond mesh.

A second subject, on which the Norwegians have been working, is shrimp separators that use something they call the "HH sorting panel." The HH sorting panel is inclined up to a hole in the top of the webbing; the fish come down the net and then go out, while the shrimp go through the panel to the codend. They tested a number of variations on this panel, including one which inclined the other way and one which was V-shaped with holes, top and bottom, for escapement.

After working on the HH panel, they tried another technique using two cones in the extension of the net, which could either use large mesh or just ropes between the cones. Another refinement is a truncated cone with an opening. Fish are concentrated in the center of the cone; there is another cone facing the other way with the apex toward the opening in the first cone, but it is of small mesh so the shrimp go through but the fish escape. They recorded preliminary results of 70-75% fish escapement.

In Scotland they are particularly worried about shrimp mixing in with Norway pout. They have been working on shrimp separators using a horizontal panel of small mesh in the trawl. This is a panel that runs horizontally along the full length of the net and then there are two codends, one above the other. There are different mesh sizes: the top codend, where you hope most fish are going, has a larger mesh size, while the bottom one, where you expect the shrimp to end up, has a smaller mesh.

They found that just by using this horizontal panel, they got 50-80% of the Norway pout in the top and 70-85% of the shrimp in the bottom, depending on where they set the panel. They varied its placement between one and two meters high in the mouth of the trawl.

This same technique involving a horizontal separator panel is used and being tested for the nephrops fisheries. They have a mixed fishery, nephrops and whiting, and their whiting are very small.

The English have been testing a horizontal mesh panel that is a half meter up from the bottom and extends from twin, over and under, codends all the way forward to just above the foot rope. They found that they could get 90% separation, i.e., 90% of the catch of mature whiting in the upper codend. They found that the immature whiting are closer to the bottom. Unfortunately, they are being caught by the shrimp codend, which has a smaller mesh. Therefore, they are still having a juvenile catch problem. They do find that, unlike the shrimp, they get all the prawns in the bottom codend, indicating they are very close to the bottom.

The Irish have also been working on the prawn fisheries and testing variations on separator techniques. They have tried shorter panels to reduce their cost. They have also tried double, top and bottom, codends with no panels and one test on a panel that runs down into the codend but does not have two codends. It's just a codend made up of larger mesh on top and smaller mesh on the bottom with one codend rope. So this system is dumping all the catch on deck in the same spot, whereas the other one is separating it for you ahead of time.

In Scotland they have taken this whole idea one step further and simply made the trawl out of two size meshes. The top is 80 mm mesh and the bottom 70 mm. There is not much difference, but they are trying to get both solutions using just this one net with the two meshes of differing sizes. They have only begun evaluations, but they said that the results are encouraging.

There were also some reports at ICES on studies of factors other than mesh size. In Scotland they have been looking at the influence of codend dimensions on the selectivity of the whole net. They found that lengthening the extension reduced the 50% retention length, while reducing the codend width increased the 50% retention length. That was very preliminary information.

The Scots also tested codend widths. The normal codend is 6.1 meters long and 120 meshes around. Then they made that half the size, 60 meshes. The narrow codend has moved the selection curve to the right. However, they are not sure why yet and are doing more work on it. They suspect it has to do with the opening of the meshes in the codend. The narrower one has to open up more. That's supposition at this time, but it's an interesting finding, because it means we may have to look not only at mesh size, but at a lot of other factors concerning the net and its design.

The German progress report mentioned that in their winter cod fishery they found the duration of tow had no influence on the selectivity of trawls. In other words, they did a series of tows of different lengths and found that the selectivity curves were the same.

A Norwegian study looked at the effect of different leg and ground cable lengths on the length composition of cod and haddock catches in a sampling trawl. They tested it with the normal 40 meter legs, with 40 meter additional ground cable, and with 80 meter ground cable. They found that the shortest rig resulted in higher catches of smaller fish, and conversely, the longer rig changed the length distribution to bigger fish. They also found a difference between the catch of each rig during day and night, which indicates there is visual avoidance involved. There was quite a bit of discussion about why it had happened, the particular tests that had been done, whether or not there had been enough information on light levels, and a variety of other parameters. Again, these are working papers and a lot of them are based on only a few tows. Some of the data may be missing, but it does produce constructive criticism.

Then there was a discussion about selection and selection studies over the years, and some of the people who have studied this carefully were commenting on the great variability in the data. Some parameters to be considered for selectivity studies include:

1. Mesh size
2. Amount of catch in codend
3. Abundance and size range during tests
4. Towing speed - flow in net
5. Vessel noise
6. Gear noise
7. Behavioral information
8. Height of fish off bottom
9. Light levels and reaction distance
10. Pressure disturbances from the gear
11. Environmental factors
12. Water temperature
13. Turbidity
14. Net design
15. Extension and Codend dimensions
16. Tapers
17. How webbing is hung
18. Mesh shape - diamond, square, hexagonal
19. Color of webbing
20. Ropes and how they appear to a fish
21. Covers, liners, and chafing gear
22. Rigging - ground gear, legs, doors, etc.

Groundfish

Square Mesh Codends

Arnie Carr
Mass. Division of Marine Fisheries

Two boats, the Stella G and the Odessa, were used in a cooperative fashion with very little compensation, other than they were allowed to get into a closed area. The vessels were very similar in size, both about 50 feet long, and used nets that were 54 x 80 feet with 5 inch webbing throughout, except for the codends. The ground gear was predominantly composed of cookies. The codend was acquired at IMP and we searched quite extensively for some codend material, looking at mesh size and at material in which the knots would not easily slip. We ended up with double-braided nylon, essentially 4.7 inches knot to knot stretch mesh size. We looked at this in the field with an ICES gauge with which we ran samples of the webbing after each tow, and found a mean stretch mesh of 4.9 inches, 112 mm, with a range of variation of about .9 inches or 22 mm.

During the tests we made six tows, each about 2-1/2 hours in duration, and the catch in the bag ranged from about 30% up to 95% of the codend capacity. The largest catch amounted to 35 bushels. The two species that were predominantly caught were yellowtail and gray sole (Figures 1 and 2). The total number of yellowtail in the diamond mesh codend over a two-day period of six tows was 739 fish and 957 fish in the square mesh bag. The total number of grey sole in the diamond was 350 and in the square 427. The catch curves are fairly similar, with a little bit of skew when you get up into the larger size on the square. A most interesting finding was, at the lower end, the curves were indeed very similar with no dramatic differences in the catch. We believed that the square mesh codend would indeed catch much smaller flatfish than in the diamond mesh. In these six totals it did not seem to be the case, at least with the data available now. I would like to see a lot more data on this and I expect we will when Phil Averill concludes the fairly extensive square mesh codend investigation in Maine.

We are quite interested in what is going on in Point Judith, Rhode Island concerning butterfish and square mesh extensions. There have been some preliminary tows, and I understand from Jim McCauley that more commercial boats will be outfitted with square mesh. They have been catching the same amount in the 3 inch square mesh as they were with a diamond extension. They also got a lot less garbage in the net.

Question, Dave Simpson: What did you use as a control to determine retention?

Arnie: Basically what we are using is two boats fishing side by side. The codends were made of the same materials and we were just comparing those tows. On the two day effort the Odessa used the diamond on the first day and the square on the second. Then we switched.

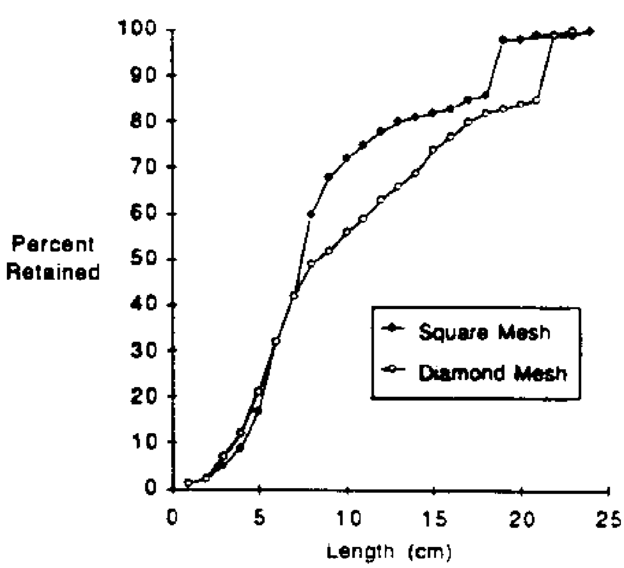


Figure 1 Cumulative Catch Curve, Yellowtail

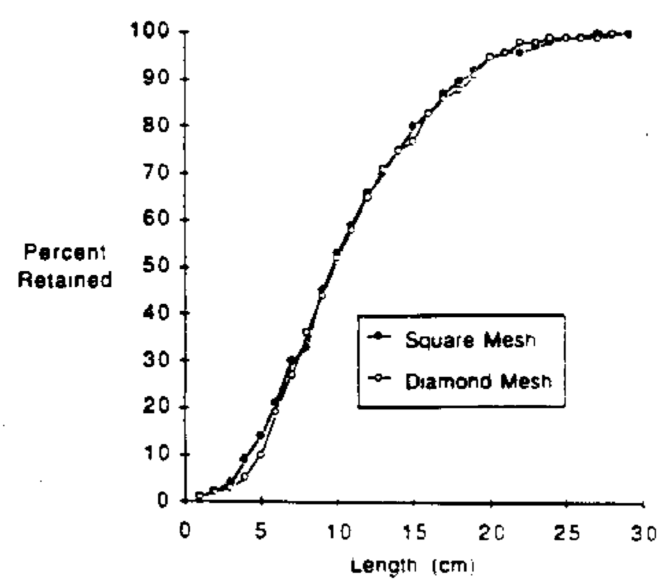


Figure 2 Cumulative Catch Curve, Grey Sole

Question, Dave Simpson: But how did you measure retention — what did you compare the catch to?

Arnie: Just to each other, that's all. Just fishing side by side, hopefully assuming that we are on the same population.

Question, Cliff Goudey: Did you have a cover to retain those that escaped?

Arnie: No, we had no cover.

Comment, Fred Manterra: I would just like to say that I am one of the fishermen from Point Judith who has used the square mesh extension and so far we have had good results. We thought we would have a problem with retention of squid. We were hoping to use it to sort the butterfish. It seems that using 3-1/2 inch (3 inch between the knot), 100 mesh tail piece, we didn't have problems with squid. We are able to keep the squid comparable to the other vessels and yet we sifting out anywhere between 25 to 50% of the butterfish. We have had good results so far with the square mesh extension.

Question to Fred, Cliff Goudey: Have you had any structural problems, assuming you are using conventional knotted webbing?

Fred Manterra: We are hanging it with 15% slack through gore ropes. One has two, we have four. We seem to have a little better result. We also have a shorter extension.

Comment, Bentley Howard: Well, from my observations using a square mesh codend for over three years, I'm happy with it and I don't think we've lost any significant amount of fish. I agree that we don't seem to retain any more small flatfish. Structurally, we haven't had any problem with the lengthening piece. Sometimes you get problems down the lower side, but using more gore ropes should help.

Comments, Cliff Goudey: It was well over two years ago that we did some preliminary experiments on models using various configurations of codends, including square mesh, and we also tried some other arrangements using diamond mesh to try to find a way of keeping meshes open. The problem that needs to be dealt with is the necking down of the extension piece and the codend itself. I think that I would agree with the supposition mentioned at ICES, that the reason for the mechanism's having poor selectivity with a longer extension is that it necks down and those meshes become essentially inescapable. The same thing goes with a larger diameter; it's only going to open up so much, and if you have more meshes around, they are not going to open up.

We experimented with gore ropes hung at a certain percentage. But we didn't spend enough time to draw many useful conclusions. It's not a simple thing to do. However, on the West Coast they have had good luck with four panel codends using gore ropes hung tight.

A lot of work on Arnie's part as gone into that study and yet there only is a small amount of data to show for the effort. It will take either a lot of money or a lot of industry cooperation to make any progress. I think the industry must begin to realize that its future is at stake and whatever cooperation it can provide in terms of helping out on these projects is going to be in its own interest.

Frank Mirachi
F/V Christopher Andrew

Square mesh: You've probably heard about it, and you've probably heard as many misconceptions as you've heard facts. If you listened to all the stories you'd think that square mesh was the single solution to all the fisheries' management problems in the Northeast, and with square mesh you could do away with all the fisheries management plans. It ain't true. You can't. It is, however, a very valuable tool and one from which the fisheries managers and fishermen, in the New England area at least, could benefit by more widespread use.

I brought a couple of hands-on models (see figures) because it's so much easier to show than to explain. This is diamond mesh, this is square mesh, it's cut out of the same piece of webbing. This is roughly 5-1/8 inch double braid poly; this is a piece of an old codend and it's now illegal to use. This diamond mesh is approximately in the configuration that it is in most codends during commercial fishing operations. This is a section of square mesh. All it is, is diamond mesh oriented at 45 degrees. The same exact thing. I've used square mesh codends intermittently for approximately 3 years.

I've had very little of what you might call empirical experience with it. Arnie Carr and his crew from the Division of Marine Fisheries came out with us for one day at the outset of my experience with the square mesh, and because of a variety of conflicts and lack of fish, we've never been able to get back together again.

Everything I have done since that first day has been on my own. What I have done, with Cliff Goudey's help and expertise, is put together four codends, one of which is made from a specialized knotless webbing that MIT procured for me from Japan, the other three out of conventional polybraid that I bought in New Bedford and ordinarily would have used for a diamond mesh codend.

Square mesh, as a device for the selectivity of allowing fish escapement, has its pluses and its minuses. Its pluses are that no matter how hard you pull on it, it stays open just like a tennis net. It doesn't collapse and the meshes don't compress. You don't get the plugging that you do with a diamond mesh if the bag is full of bottom trash.

The minuses are that with a given mesh size, the selectivity for flatfish goes down. In other words, you get a smaller size flatfish retained than you do with an equivalent size diamond mesh. Obviously, the reason is that the diamond mesh with a long axis allows a flatfish to go through flatwise.

With the square mesh this diagonal is shorter, so a smaller flatfish gets retained but a bigger roundfish will go through. In other words, the selectivity works in the reverse for roundfish. A cod fish, haddock, or whiting would go shooting right through the square mesh, but it will be retained by the narrowness of the diamond mesh. So fisheries managers have their work cut out to pick out the right mesh. The right mesh for square mesh is not necessarily the right mesh to be used in the diamond configuration. As a matter of fact, axiomatically, it's not the right mesh. It's going to have to be bigger mesh for flatfish, but a smaller mesh for roundfish; leaves you with a dilemma that I don't purport to solve here today.

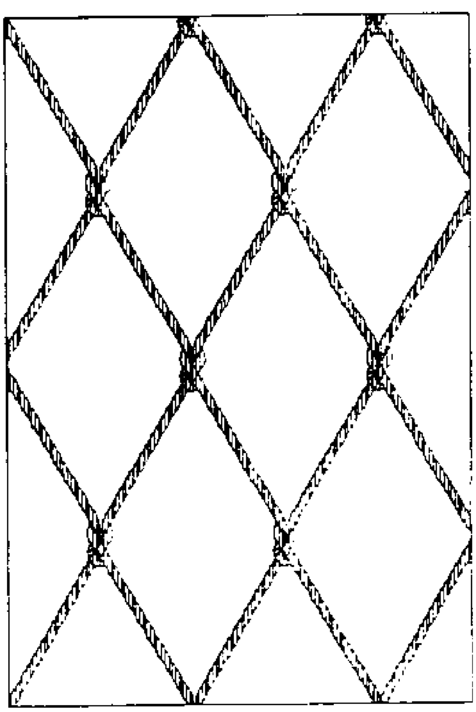
As far as the mechanics of using a square mesh are concerned, it's wasteful until you get down to making them on a production basis. If you're making one, you end up cutting a diagonal chunk out of the middle of a rectangular square of webbing. You lose quite a bit. You can put the piece together, but it's time consuming and it's one more thing that most people don't have time to do.

Once it's made, however, it also presents some unique problems. With the stresses in the codend running longitudinally, the first thing that happens is the knots will slip. The codend that Cliff provided for me from the knotless webbing was the only solution I can see for preventing these knots from slipping. When they slip, you end up with a rectangular mesh instead of a square mesh. The longitudinal bars get longer, the circumferencial bars get shorter, and you end up with long, skinny slits.

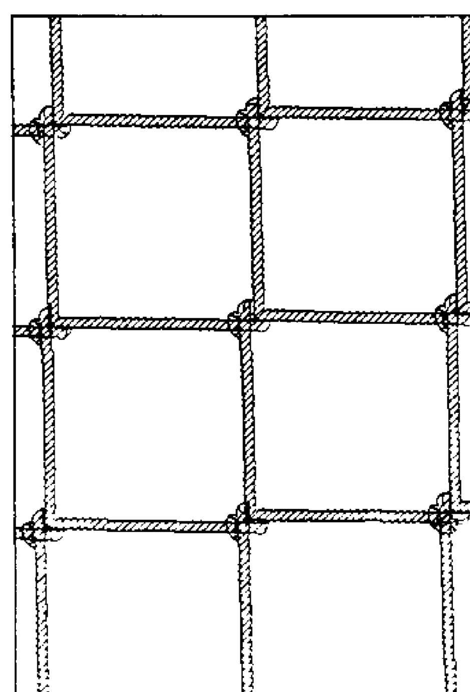
What I have done to try to minimize that eventuality is to put helper ropes on it. The helper ropes work to an extent, but I've never tried it with more than two. The helper ropes stay well, but on the front and back of the codend you end up with a big pouch where the meshes are elongated, and the helper ropes retain their original length. Consequently, you get a lot of mesh distortion. Four helper ropes would probably be better. Maybe even six helper ropes would be essential in order to keep the meshes of the codend from distorting. The best solution is the knotless twine, but it is very, very difficult to get.

Another problem is strength. The size of the codend that I am using is comparable to the 60 mesh bag that is standard on boats of my size. The square-mesh codend, which is 50 meshes in circumference, has 50 longitudinal bars holding all the weight. A 60 mesh circumference diamond mesh codend has 120 bars bearing the same amount of weight. You have less than half the strength in the codend itself plus, in all probability, the tension strength of the knots are reduced because it's pulling sideways, rather than the normal way.

As I already mentioned, square mesh is a much cleaner way to go fishing. You don't get the bottom trash; it drops right through. Also, with the proper mesh size you get a knife-edge, or close to a knife-edge, selection of the fish size that you want. It will minimize the discards, but you do have a problem with the difference in selection between the roundfish and the flatfish.



Diamond Mesh



Square Mesh

One thing that I haven't tried that sounds very promising is, instead of using square mesh for the terminal portion of the codend, using it as an extension and using the diamond mesh at the terminal. I think this has more promise than anything else. That combines the best of both worlds by allowing the small roundfish and some small flatfish and bottom trash to drop out through the extension, and then the diamond mesh along the end selects the flatfish.

So, basically, square mesh is an idea that requires a lot more work. Arnie Carr has done some work independently of my boat. He spent several days on a boat in Gloucester. He has a fairly extensive program, but not nearly extensive enough to investigate this problem. He has had a problem with manpower and fish availability. Phil Averill, I believe, also has a program, which he is about to embark upon, involving square mesh. I believe that it's going to be used pretty much in the extension.

All I can say is that, from my experience, square mesh does work. I have used it commercially for three years, principally in the winter, since it's not compatible with dogfish. I intend to use it again this winter. I'm going to try it in the extension rather than the terminal portion. I think it will work and I certainly would urge anybody that is interested to give it a try, or at least read up more extensively on it because it does have certain very profound advantages in allowing the escapement of small fish - if it's done right. The most important thing that we can do today is manage our catches to allow the escapement of immature fish. A major problem in fisheries today is poor selectivity in trawl nets. In all probability, the square mesh alone is not going to be the single solution, but the square mesh in conjunction with other methods of fishing gear engineering will spell the answer to the seemingly insolvable problems of controlling the mortality of our fishes without encumbering the fishermen to the point where they can't go on fishing.

Northwest and Alaska Experience

Bill West
Nor'Eastern Trawl Systems, Inc.

In the Northwest, management efforts have not included regulations concerning the physical structure of the gear to manipulate gear selectivity. Our management's approach typically has been to define allowable catch levels, to designate a legal gear by which those catch levels may be obtained for that particular species, and then, when that amount has been caught, to shut down the fishery. It has been like this, in part, because of the many factors, which have already been discussed, regarding different structural effects on selectivity. If you try to do fine tuning of selectivity by choosing a particular mesh size, then you will quickly find out that, in order to obtain the desired results, you run into too many structural restrictions.

It's been the preference of Northwest managers not to get into too much of the details of dictating the structure of the gear. They prefer to let the fishermen make their own choices about efficient and economical harvesting mechanism.

The efforts that have been made in the realm of selectivity, with a few exceptions, have largely been made by either the industry itself or been initiated by the industry's urging. Their purpose has been to solve problems that the industry perceives, not because the managers think they can fine-tune the harvesting process. Typically, the industry has wanted this type of selectivity work done because of political and allocational type problems. There are certain species that may not be harvested by trawls. Halibut is one, crab is another, and salmon is a third. These are called the "prohibited species," and if they are captured in a trawl, they must be returned to the sea. They cannot be consumed onboard, nor sold, nor kept. So, this seems a little stringent and the guys don't like it. What they really don't like is the ever-present specter of being shut off from a ground because of the occurrence of these species. It's a pretty harsh measure to close down a grounds in order to keep trawlers from catching a particular species, but it has been done, and the draggers want to prevent that.

The fishermen have been interested in developing gear types that will not negatively affect these prohibited species. To some extent, they have been pretty good about policing their own efforts and staying off nursery grounds and breeding areas. On the whole, they have been pretty forward looking about it. They realize that they are vulnerable on this issue and they are taking a lot of initiative.

In 1985 I was involved in an NMFS project aimed at testing codend mesh size. The west coast rockfish fishery had been a productive and valuable trawl fishery in the past. However, these are very slow growing, long-living fish, and it didn't take too long for their levels to get knocked down. Management's response was to institute stringent trip limits, both in duration and in the number of trips that can be made during a time period, and restricting the maximum amount of catch that may be landed at the end of each trip. The fishermen didn't care for this. It seemed to them that the effect of these regulations was unfair because it tended to favor small boats over large boats. A small catch, delivered every now and then, wasn't too tough for a small boat, but for a big boat, that small catch within that time period would drive them into bankruptcy. So they have requested strongly that National Marine Fisheries Service and the Pacific Fisheries Management Council do studies aimed at determining the selectivity characteristics by which different management schemes may be implemented. What they would have really liked is some magic codend size that would allow them to go out and fish all of the time, and makes lots of money, and still have a large, unending resource.

The situation is complicated by the fact that the rockfish fishery is targeted on mixed species. Depending on the area, you have anywhere from a dozen to three dozen commercially valuable rockfish species occurring on the same grounds, all maturing at different sizes and different ages. You get senile fish in some species that are the same size as other species fish that are not yet sexually mature. Trying to find one codend mesh size that will suit conservation needs for all of these species and all of these different sizes is going to be a tough problem. But, because it was such an urgent question for the fishermen, we took a shot at it anyway.

We tested four different codends using an Aberdeen-style, hard-bottom trawl with a roller groundgear. One codend was of three inch conventional diamond mesh. This is the legal minimum for that fishery and it is the size that at least half of the fishermen use. They may use larger if they wish.

We also tested a codend with three inch square mesh made out of Nichimo-VC netting, which is a four-strand, braided, knotless polyethylene material. Our experience with this material, in terms of structural stability, was very good. The meshes didn't slip, it didn't stretch, and it looked brand new at the end of the experiment. Also, it's a very popular material in conventional codends because of its great strength and excellent wear properties. It turned out to be excellent material for square mesh codends, and it's worth considering if you're going to do more square mesh studies.

In total, we tested 3-inch diamond mesh, 3-inch square mesh, 5-inch diamond and 6-inch diamond mesh and, to make a long story short, we determined that the 3-inch square mesh had a higher and steeper selection curve then the 3-inch diamond mesh. In other words, our 50% retention length for the species that were caught in both nets was higher and there was less slope to the curve, which is what you would hope to see with square mesh. The 5-inch and 6-inch diamond mesh codends retained very few fish. The catches were very low with those two mesh sizes. That left us with the need to try some intermediate mesh sizes, something in the range of 4 to 4-1/2 inches and also the need to look at square mesh some more.

We had no significant amount of gilling in any of our codends. There were concerns that there might be severe gilling in the square mesh and it just didn't happen.

We used a combination of the alternate haul and the covered codend approaches, using the pooled catches from the cover and the codend within it as the control against which we compared the conventional codend catches. It turned out that we got severe masking, so we did not use the cover data as such. The NMFS is still trying to find a statistically valid means for examining the significance of the results. That has been going on for two years now, and perhaps they will have found one by the time I retire from Nor'eastern Trawls .

On the West Coast we are also looking at various means for separating fish from shrimp catches, and we've looked at one of the designs that was mentioned by Al Blott. Once again, this is a voluntary measure on the part of the industry. There is no real conservation problem here. The shrimp fishermen fishing for *pandalus borealis* may keep any fish they catch. Their interest is just a matter of their own convenience. They don't like to sort small fish, especially smelt and juvenile flats, out of their shrimp catches. It's a nuisance. So they would like to find some means of getting rid of the fish. The big fish that they catch, however, such as cod or a big rockfish, they generally keep.

I spent a year in Norway in 1984 working on this concept. With the most successful variant of this design, pictured in Figure 1, we reduced fish by-catch by 50% while catching equal amounts of shrimp per hour compared with a conventional codend. The average size of the shrimp in the side with the separator was quite a bit higher than the size of the shrimp in one without the separator. In other words, we were getting rid of the little ones and catching more of the big ones. I don't know how that happened. We were using what we called a "siamese twin trawl," which consisted of two half trawls joined side by side. One side had a conventional codend and the other side had the separator. This gave us a built-in control by which we could compare the catches.

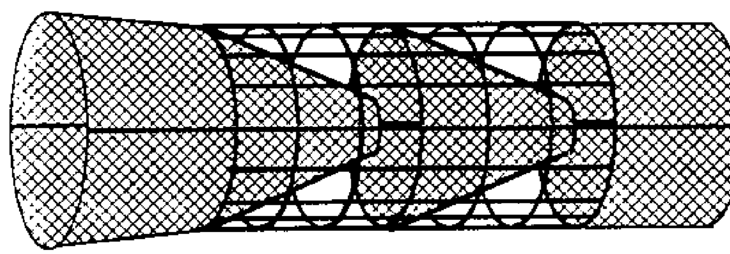


Figure 1

Unlike a Gulf Coast twin trawl there was no dummy door, just doors to port and starboard. This was a single rigged trawler towing with a port and starboard half trawl. We tried to make sure when we were towing along a slope that one side was uphill half the time and the other side downhill half the time. We are anxious to try this separator again in a commercial fishery. I am looking forward to getting the results. I was hoping that I could give you some preliminary results at this meeting, but it hasn't been used yet.

In the Bering Sea yellowfin sole trawl fisheries, there has been some concern about by-catch of king crab and other species, such as tanner crab and halibut. The real problem, however, has been king crab because of the high value and the currently depressed state of the resource. The Bering Sea is a very productive area. It used to be a very productive area for king crab, and it is still producing large amounts of flat fish and pollock and other round fish species.

There has been a conflict regarding the possible destruction of king crab by trawls. The trawling participants realized that this was a bad situation and, to some extent, they weren't being altruistic. A lot of the trawlers go crabbing during the off-season because they make a lot more money crabbing than they do trawling. They are protecting their own interests as well when they try to leave the crab alone. They very quickly took measures, which were easy to implement, to reduce the by-catch . One involved placing crab panels of very large netting right in the belly of the trawl. Typically, a 16 inch stretch measure was placed right behind the center of the foot rope. The idea here is that the crabs that actually enter the trawl will tumble out through these large openings and return to the sea bed unharmed.

Another measure was to avoid areas with high by-catches of crab or halibut. When they hit one of those areas, they would move elsewhere. There were also various rigging and towing speed alternatives that were tried. It's possible to organize these conservation measures because most of the sole fishing in the Bering Sea is conducted for the Marine Resources Corporation. This large joint venture operation involves Soviet processing vessels that purchase their codends at sea from the U.S. draggers. The Marine Resources Corporation required its fishermen to use a certain trawl design rigged for reduced by-catch and to tow it at a minimum speed. Anyone's operation that caught too many crab was shut down. The Marine Resources Corporation is doing its own policing and has been very effective in reducing the by-catch.

However, questions remain and there is valid and legitimate concern that the by-catch was only part of the picture, and maybe not even the important one. The crabbers were concerned that the rigging of the trawl was hitting the crabs and crushing them; the sweeps, mud gear, lower bridle, and the rollers were smashing crabs. Fairly extreme scenarios were put forward depicting the amount of carnage being reaped by these trawlers, even though their by-catches at this time had fallen to very low levels due to the various voluntary measures. It was felt that the National Marine Fisheries Service needed to get involved and do some kind of impartial study on the impact of trawling. The only feasible manner for studying this was to use some kind of direct observation technique, so the Manta underwater towed vehicle, equipped with T.V., was chartered.

Our goal was to put the Manta down onto representative sole gear and observe what happened to the crab. That was a good idea and if it hadn't been for the turbidity, we probably would have done it. As it was, we found that in the areas where crab could be caught, the water was too turbid and too deep for the TV camera to work. In areas where viewing conditions were acceptable, there were no crabs. We did spend a few days looking for decent viewing conditions, and then we spent the remainder of our time watching the physical performance of the trawl. By studying the physical performance of the trawl, we were able to draw inferences about its potential for harming crab, and thought about various means that we might take to reduce the impact of trawling on crabs.

The net we used is what we call a "Bering Sea Combination." It's similar to the Aberdeen-style trawls and is a very successful flatfish trawl. Probably 80 or 90 percent of the boats fishing in the Bering Sea for sole are using the Bering Sea Combination or something very much like it. The surprising thing is that this trawl has cutaway lower wings. It is usually built with about 8 inch stretch mesh in the body, and a codend of 3-1/2 inches.

We actually took the vehicle into the trawl on several occasions and made observations of the footrope from there. We were able to get into position on the center of the head rope to make our move over the top and down into the mouth. This was always a fairly tense moment. We actually got the vehicle wound up in the footrope once.

The Bering Sea Combination is fished in the Bering Sea for sole, but it's not fitted with what I call a "continuous cookie footrope." The footrope is made up of chain or cable threaded with 3 or 5 inch rubber cookies, and then every 2 or 3 feet there is an 18 to 20 inch diameter bobbin or just a big disk. It's more of a roller gear type of footrope. When this type of footrope was introduced in the Bering Sea, some people were concerned that flatfish would escape under the foot rope in between these big disks. But in fact, that didn't happen because the heavy mud plume that is churned up by the big disks actually fills in the spaces between them, and often times obscures the small diameter cookies completely from view. So, the fish are seeing this big cloud, with occasional black disks, sweeping towards them. It seems to be a very disturbing stimulus that they tried to avoid.

A lot of flats actually entered the trawl upside down. They would swim along in front of it, right side up, and then, when they turned to enter it, they would do a barrel roll. This, when you think about it, is the most efficient way for a flatfish to make a 180 degree turn. So they exhibited the typical fish behavior that you've all seen from the Aberdeen tapes. In the wing areas they would swim at an angle in towards the mouth, and when they finally arrived at the center of the foot rope, they'd swim along in front of it as long as they could. Then they would rise, turn, enter the trawl, and swim back to the codend.

A useful observation was that you did not need a real heavy footrope digging hard into the bottom to catch flatfish. This relatively light footrope was rigged to fish light. It is the preferred gear for catching flatfish. We weren't on the really productive grounds for our experiment and were catching only 6,000 lbs. an hour. The vessel was a 130 footer with about 1300 horsepower. We were trying to duplicate the operations of the joint venture fisheries and they do most of their dragging between 3 and 3-1/2 knots, so that is where we stayed. A few vessels tow up to 4 to 4-1/2 knots.

We made a very interesting observation that countered the arguments that the rigging of the trawl was killing crab. The sweeps and mud gear in the bridles were off bottom until you got almost to the wing ends. What we call mud gear is cable threaded with 3 inch cookies and 8 inch disks, spaced every 5 fathoms. These big disks are just a big chunk of tire. We saw flatfish being herded by this thing even though it wasn't touching bottom. It would sag down every now and then and suck up a puff of sand.

If we had been towing slower there would have been more of this in contact. What we found was a gradual curve starting way off bottom at the doors where the wires are suspended halfway up the height of the door. Then they sag down and touch in the middle and they back up again to the bridle junction, which is about half the height of the wing end. Then the lower bridle starts sagging back down again to where it joins the wing end. At Nor'eastern Trawl we are going to put weights at that bridle junction in order to bring that whole part of the gear into closer bottom contact. Doing so should not cause any significant increase of crab mortality, since the bulk of the mud gear will always be held off bottom by the height of those big disks. They should allow plenty of room for the crab to get out. Even though the bridle intersection was off bottom, it still herded fish fairly effectively.

We made a few tows with what we termed the "old style" trawl, which was typical of the trawls used prior to the time that the crab issue became important. It had a very heavy foot rope of heavy chain threaded with 12 inch diameter disks, packed solid, and had two foot of setback at the foot rope on each side. We caught a lot of clams, starfish, mud, and all kinds of bottom junk with the old style trawl. On the other hand, with the light ground gear on the Bering Sea Combination, we caught very few starfish and no clams.

With the old style trawl the footrope appears as a very solid, heavy, continuous black line of disks. It's all down hard on bottom and it kicks up a big, continuous mud cloud. The interesting thing is that the fish responded to this in exactly the same way that they did to the lighter ground gear. It is pretty obvious why they would want to avoid this thing. So, once again, it seems clear that it's not necessary to actually dredge the Bering Sea flatfish out of the bottom in order to catch them.

Towards the end of the trip we suspended vehicle operations. We went back into an area where crab were abundant and made some comparison tows with the two trawls. We didn't make enough tows to get a statistically significant sample. However, we did make a few tows and observed that the old style trawl caught many crabs, whereas the new style trawl did not. Both from the vehicle observations and from this limited amount of comparative towing, there is reason to believe there is a real difference in their impacts and a real difference in the way they worked.

The body of the old style trawl was in many ways similar to the Bering Sea combination. It is a derivative of the Atlantic Western series of trawls with cut away lower wings. This trawl is made out of black nylon instead of orange poly, so you can't see the webbing quite as well. Again, we maneuvered above the trawl and then went down into the throat. We made a one hour tape, a first attempt at editing the significant observations made from some 18 to 20 hours of videotapes we got from the three week cruise.

The most difficult part was getting the vehicle launched and recovered. We flew it around the warps and nearly sucked it into the wheel a couple of times. We also got it under the footrope once or twice. That's something for future vehicle users to think about. It's good if you have a reliable, functional vehicle that does everything that you want it to do. But, another part of the equation is getting it in and out of the water. That turned out to be as big a headache as anything else, if not the biggest. The vehicle was damaged, which affected its durability. We'd get failures later on that were the result of getting flown around the warp.

This research is still an issue. There remains concern that not enough has been done to reduce the impact of trawling on crab. Nor'eastern Trawl, the National Marine Fisheries Service, and a number of other industry groups will be continuing these studies this coming summer. This time it will be more in the style of gear development; first, using the flume tank that Cliff runs; then, whatever we come up with in the flume tank we'll take out and test in a comparative fishing exercise in the Bering Sea, using joint venture catchers and processor vessels contributed by the joint venture companies. It's really a heartening thing that the industry is putting so much into this kind of effort. They are providing a lot of money and a lot of effort. They are trying to keep themselves from getting shut out of the Bering Sea.

Question, Joe DeAlteris: What was the actual visibility on the bottom?

Bill West: When things were really good, we could see 15 or 20 feet with enough detail to recognize what we were seeing.

Question, Joe DeAlteris: Is there any effort being made to get TV cameras down to the bottom where there are good crab populations, take the trawl over a few times, and then go back again from a biologist's standpoint and look for damage to the crabs to determine the impact on the bottom?

Bill West: Yes, we made an effort to do that during the project last spring. What we found was that in the areas where crab were abundant, it was so dark that we couldn't see anything without using the lights. When we used the lights all we saw was the phytoplankton. That wasn't very successful.

The Fishing Industry Technology Center, in Kodiak, has applied for Sea Grant funding to conduct exactly the kind of study that you're talking about. They are going to work in a shallow bay on Kodiak Island, send divers down to do transects in this bay, and do a complete benthic community inventory. Then they will drag a trawl through it several times, and then go back and assess the impact of the trawl on the benthic community. This is generally a worthwhile thing to do. However, its applicability to real world fishing is somewhat questionable, in that the water they are working in is so shallow, and the benthic community is going to be very different from anything you would find on a real fishing ground. I don't know how safe it is to generalize from one area to another. Also, gear performance is going to be significantly different in such shallow water from what it would be in a normal situation.

We also towed the vehicle over the track of the trawl a couple of times. The boat had an extensive suite of electronics, including a plotter, so we were able to pinpoint exactly where we had towed and we made zigzags across the course that we had already run. On a few occasions we were able to detect the trawl path. We could see scrape marks from the doors, but that was it. That says to me that the trawls just don't do very much damage. Of course, the bottom in the Bering Sea is a very fine, well compacted composite of sand and clay. It is tough stuff and it is not going to stir up as a silty or muddy bottom would. On a softer bottom you might see a lot more of the impact.

After the cruise we were informed that we had not had optimal camera performance, due to problems with the cable that were discovered later. So, theoretically, the resolution should have been better. We were able to make qualitative observations. However, we certainly weren't able to make species identifications from the TV image and it's questionable that we were seeing everything that was there. I figure an object had to be pretty big and pretty conspicuous before we were able to see it on that TV image. Now the MANTA and other such vehicles are often equipped with still cameras for which the resolution is very good, but you've got to run lights all the time. There is no perfect vehicle that I know of that does everything really well.

We had a tough time up there. A lot of it had to do with the difficulty of deploying the MANTA from a trawler. We needed a much more sophisticated launch and recovery system. On a dedicated research vessel, where you are going to be using it all the time, it's possible to fabricate something that will get it in and out of the water more easily. I do not regard it, in its current configuration with the launching system that we were using as a viable tool for trawl observations. John Watson and his colleagues down at the Southeast Fisheries Center are working with a MANTA II vehicle and they have worked out a system that operates pretty well. I don't regard the MANTA as something you can easily use aboard a vessel of opportunity for trawl observations.

Bottom Pair Trawls in the Gulf of Maine

Richard McLellan
F/V Irene's Way

We are doing some in-depth pair trawl research because, as all of us Mainers know, our resource isn't like that of the West Coast. We are in deep trouble and we've got to do something about it. For those of you who aren't familiar with what bottom pair trawling is, it's two boats of relatively the same size and horsepower towing one extra large trawl between them. The catch area of the bottom pair trawl is roughly 3 to 5 times that of a single boat of equal horsepower. The pair trawl that we are presently using is a basic design and looks very much like the common Shuman trawl that I have been debating about for the last 10 years.

The trawl that we are using is a 190 foot sweep with a 150 foot headline, making it quite a bit bigger than a single boat trawl. The other difference in our pair trawl from a standard single boat trawl is that we use 8 inch mesh front ends. It's 4 mm polypropylene twine in the wings, the square and the first two bellies. Behind this we use a 5-1/2 inch mesh, 4 mm twine, from the second belly to the codend.

The catch area, or the distance between the ground cables, is between 550 to 650 feet on the trawl we're presently using, as compared to 150 feet on our single boat rig. It seems like our catch rate is pretty much in proportion to the increase in catch area.

There are a couple of other benefits we have noticed that I think are interesting. One is the excellent quality of the pair trawl's fish. By using this large mesh front end and 5-1/2 inch backend, we retained only large fish, no juveniles. Instead of lugging around big bags of 10 and 12 inch whiting, haddock, and cod fish and destroying the good fish you have, all you end up with is the good fish and it really makes a tremendous difference. One of the physical characteristics of Shuman-type bottom trawls is that the codend never touches bottom. We've had the same codend from the very start. We've had a number of hauls of 20,000, and the codend simply never hit bottom. You never see any mud;you never see any scraping; it's a beautiful product.

The fishing circle in our standard bottom trawl is 190 feet and the fishing circle in the pair trawl that we are presently using is 385 feet. It's quite a difference. We tow a larger trawl about twice as easily as we do single boating with a much smaller trawl. We found the fuel consumption is cut by a little over one-third. Our gear bill has dropped down by at least one-third. We just don't seem to do the damage. We don't have to get into the bottom to get the fish, but when we do, the damage that's been done usually takes a bale of twine to put back together.

While I don't think this trawl is the last word on how mesh size should be arranged, it has been extremely successful for us. Since July, we've documented over 325 tows in depths ranging from 32 fathoms down to 165 fathoms. We've towed on flat, smooth bottoms as well as over pinnacles that would just scare you to death.

The main reason for making this comparison is to show that it is probably not so much the bottom pair trawl that is being selective as it is the large mesh sizes we are going to be using. I hope all the fishermen working in the Gulf of Maine and on Georges Bank agree, as we do, that the 5-1/2 inch mesh size will probably play the biggest role in rebuilding our ground fish stocks. Conceivably, if we can fish within the 5-1/2 inch law this year, next year we won't have to put up with even stricter regulations that we won't be able to live with. I assure you it is pretty tough for a fellow to pull a trip from Georges or the Gulf of Maine with 5-1/2 inch, but the good fishermen are doing it and the other fellows are going to have to learn how to do it.

I would strongly encourage all our fishermen to help police this regulation, because I can see right now that that it's the biggest problem we are having. We know how to regulate the fish. It's getting all of the fellows to do this that is the problem. Since it is our own careers that are being jeopardized, I think it's up to us now as individual fishermen to do the policing, because if 5-1/2 is going to make us struggle, you can imagine what 6 is going to look like when that comes down on us next year.

I went to Scotland this last summer to look at what those fellows are towing for gear over there. It's just incredible. So, I feel optimistic that with the many technological advances in the fishing gear and harvesting systems, and our ability to test fishing gear and to update fishing techniques, the fishermen and the net builders can update fishing techniques. We now have enough information, from both our own domestic net builders, and people like Cliff, and from studies done on all types of gear. We can construct our own effective system of harvesting catch controls that everyone can live with comfortably. I think we are all bright enough to do that now. We hope the variety of selective fishing gear at our disposal will aid us in our urgent efforts to attain some kind of good husbandry and effective management. I hope you all agree with that theory because if we don't, we've only been at it for a month and half and the fleet is divided already. Some are still using small mesh and we've got to do something about it. I think that if the fishermen do it and the fellows on the shore do it, then the government won't do something that we really can't live with.

We use incredible lengths of ground gear, as much as 450 fathoms in front of the trawl, and it was great in mud. I think it would really be effective on flatfish if you didn't get mudded up all the time. We've gone all the way back to using 60 fathom of ground gear, and on our round fish it doesn't seem to make a bit of difference. However, we found that we lost a lot of headline height. We used a Scanmar machine for a trip that gave us exact wing end spread and headline lift. When we put out long ground gear, it bowed out so much that a normal spread of 85 feet went to about 110 feet. But when you've only got a 150 feet headline that doesn't make a very fancy trawl, and we'd get big bags of mud and very few fish.

When we shortened our ground gear, we attained good heights. The best we did at two knots was 31 feet. At 2-1/2 knots we got a consistent 24 feet, and in one situation we went fair tide and got 27 feet for the whole tow, and that was a 25,000 pound haul. So you can see that there are all kinds of combinations in this pair trawling that have to be figured out. If you get up in the hard bottom and you use too much ground gear, you're not going to have a net left. Ground gear seems to go to pieces very quickly: we only get one trip from half of our ground gear and then we have to replace it at $550 a set. That is one of the bad features.

One of the good features is the day before yesterday we were working a piece of ground close to Georges Bank with two other stern trawlers about the size of the *Irene's Way*, 85 feet with 650 hp. We were comparing notes with the other fellows. First, one guy hauled back and had 1500 lbs. We had taken a little ride around this area and had found some pretty good indications, so we set about between the two boats so that we could compare. I've known one of them for years and he is an honest fisherman. He had 1500 lbs. for 4 hours and the other fellow had 800 lbs. We had 20,000. That was for almost the same exact tow time. So we tried it again. The next time, one of them got a hole in his codend with a boulder and the other fellow had a 2500 haul. We had seen just a few more indications that haul and we had another 20,000. So we picked up 80,000 in 2-1/2 days and just about killed the crew. A 20,000 pound haul in the Gulf of Maine right now is unheard of, I can assure you.

On the same trip we made a couple of tows with four or five boats in the Boston fleet. Once again, they are pretty good fishermen towing similar gear. One fellow had 35 fish and I think he was towing fairly small codend. We got 1800 pounds with literally no discards at all, none. We've had, once again, hauls of 20,000 lbs. of fish and did not have to throw one away. So you can see how selective this mesh configuration is, but it doesn't necessarily have to be a pair trawl. I think what a pair trawl will become, as the Gulf of Maine gets cleaned up, is an out for everybody because you can tow these pair trawls in the wide open country and catch enough fish to make a living. I think that is where it's going to shine. So Paul Shuman and Nor'eastern Trawl better start making some pair trawls, at least for the fellows up in Maine.

Shrimp

DMR Separator Trawl

Phil Averill
Maine Dept. of Marine Resources

The Fisheries Technology Service is part of the Department of Marine Resources in the State of Maine. We areabout to embark on a square mesh project. It will be five months in duration and will be funded by the Maine Fishermen's Forum, which is a new group that you may not have heard about. We've all heard about the Fishermen's Forum in Maine which is a one weekend deal, but The Forum Incorporated is now a year long research group with a Fisheries Technology Institute, and as their first project they have chosen to fund my group for a square mesh project.

We've been working on a shrimp separator trawl for four or five years. The primary cause for this long delay has been the vessel that we have been using. Within the past month, we have been fortunate to obtain another vessel and we are going to retire the old *Explorer*. She is quite well known. We now have a real fishing boat, a 40 feet Webber Cove, so we hope our work will proceed a little more quickly.

In the beginning, fishermen came to us saying they were killing all the baby flatfish. They had a very high flatfish by-catch in the early part of the season, particularly in the midcoast area from Boothbay up to Rockland area. Fishermen came to us and said they wanted to catch those fish when they matured five years later. Could we do something about that? So we looked around and saw there were a number of separator trawls that had been built over the past 40 years. There was nothing new about them; they were designs that had been built all over the world. We looked at all the designs.

But what we want to do is a little different. When we're catching shrimp, we have a very good fishery for a market size cod. In the early part of the season, the codfish are frequently worth more than the shrimp. So we want to develop a trawl that saves the shrimp and the large cod fish, but releases the baby flatfish, the baby codfish, and all the trash. Most separator trawls released everything except the shrimp.

We came up with a Newfoundland design which is a double codend design with a panel. We tried it and didn't work worth a damn. We modified it a great deal and we came up with the net that we have now, which does work. We had it on commercial vessels last year. This net design will be in the next issue of Commercial Fisheries News. It has some problems, it's not perfect, but it works. We will be getting into some modifications of the net under the S-K project that we hope will make it work better, be easier to build, and solve some of the problems I'll mention here.

Initially, we were developing this net in the same old way, by towing it and looking at the catch. We were going around and around in circles and not getting very far. We had two different designs. We couldn't decide why they worked differently. We really couldn't tell anything. Thanks to Cliff Goudey and MIT Sea Grant, we got the net down into the Bethesda tow tank. This is a tremendous body of water through which you tow a net. It is the one that is next door to the facility where Cliff gives his courses. Our 26 x 32 separator trawl was small enough to fit in that tank. I believe the tank is 52 feet wide, 3000 feet long; it's a tremendous thing. We towed this with a carriage that runs over the tank. I brought a glass bottom skiff along so I could look at the trawl.

The critical point is where the panel comes up and joins the upper extension. We were having some problems in tapering that panel. It's a typical shrimp net; Ken Gray of Coastal Net Company in Warren, Maine did a great job for us. The panel rises from the foot rope to the back of the upper belly where a second extension and a second codend go on. Fish come in; see the twine of the panel; they ride up the panel and go into the upper codend where we have 5-1/2 inch or 5-1/8 inch mesh. The small fish go out and the cod fish are retained. The panel is 3 inch mesh hung on a square giving a nice big hole, allowing the shrimp to go down through that mesh. We do not know if that's an active or a passive process. From John Watson's tape of the Gulf of Mexico, it looks like a passive process. We have evidence that the shrimp might be burrowing down through the panel as an escape reaction. They do go down through the panel into the lower codend where we have the 1-3/4 inch mesh.

We tested the effectiveness by having a 1-3/4 inch codend on the top so we could see how many shrimp were actually going up above. Then, when we went to commercial trawls, we changed to the 5-1/2 inch upper codends. There was no change in the shrimp catch. We did most of our work in the small mesh upper codend, trying to save these little flats and any shrimp that went the wrong way. So we know what our retention rates were.

What is getting mixed in with the shrimp now is cigarette mostly whiting and brit herring. We have most of the small flats out of there. Just a scattering of shrimp are found in the upper codend and they would have been lost if we were using the 5-1/2 inch codend.

We've been averaging a shrimp retention rate of 95%. We said that this net will not work unless we retain at least 90% of the shrimp. It's just not feasible for industry to take more than a 10% cut. We've done better than that and are consistently up around 95% retention now. We are up to 100% market size fish going into the upper codend. As I said, about 50% of the whiting and 70-80% of the brit herring are mixed in with the shrimp, and that is one of the problems we are hoping to solve with the "Mark 2" net. The other problem is that on occasion, a skate will get its nose stuck in the panel and get plastered against the panel by the water pressure. This creates a pocket and it fills right up with trash and mud. It is a pain to deal with but it's not insurmountable. That happens about 25% of the time.

We have already had the net rebuilt. As a matter of fact, they are finishing it today and I hope to pick it up tomorrow. We have redesigned the panel going up into the upper extension to improve the shrimp retention.

That gives you an idea of where we are and what we're doing. The two things we are going to try next is change the way that the panel lies and go to a slightly bigger mesh on the panel. We have been using 3 inch, but started off with 2-1/2. We haven't changed from 3 inch. I think we could get away with a litte bigger mesh and still get most of the fish going up. We have changed the way the panel breaks up into the upper codend. But what we are interested in are these funnel separators that Bill West mentioned. When I was over in Scotland this spring at the Aberdeen lab, I got some videotapes of the Norwegian funnel that they use. I guess it was developed when Bill was over there.

What we are thinking is that we will go with a much bigger panel, one that is not quite so critically hung. It is now more critical than I want it to be. There is a little slack here and there that doesn't make much difference. We'll put one of these funnel separators down in the lower extension where the shrimp are. Using the panel to get our big cod fish and marketable fish up top, we would then use that funnel separator to get rid of the slim-bodied fish like the herring and the whiting. They aren't a real problem. That's mostly for the convenience of the people on deck. We can live with the herring and the whiting mixed in with the shrimp. They are fairly easy to pick out. The main thing we did this fall was the baby flats that do go up.

Question, Paul Christian: Has anyone in your area used the rigid frame devices developed down south?

Phil Averill: Other people have, but most of our nets are run on the net reel and that would prevent their use. Other people have tried it and it works, but it tends to be more of a nuisance to bring the net in.

Southeast TED Experience

John Watson
NMFS Pascagoula Laboratory

I think that with our work and with what I'm going to show you, it is more important to look at the techniques involved than the hardware. The hardware may not apply to the problems in the Northeast, particularly because of the difference in the species and the difference in the behavior of the animals. The way we approached it probably has some application in other areas.

In 1977, we were approached to try to develop a piece of hardware or gear that would eliminate sea turtles from shrimp trawls, or at least reduce their captures. This was a significant problem in the Southeast. During the process of this work we did quite a bit of diving on shrimp trawls. We were able to observe shrimp and fish behavior.

The work was done by the National Marine Fisheries Lab in Pascagoula, Mississippi known as the Mississippi Laboratory. The TED, originally called the "Turtle Excluder Device," is basically a framework that goes into the extension section of the trawl. It originally was designed to reduce the capture of turtles. It has a grid section that is put in to the codend that physically stops turtles and other large objects and allows them to come out through a door on the top.

We evaluated a lot of designs to come up with the current design. The grid basically keeps the larger objects out and has an advantage in the Gulf in finfish separation. All the panel-type separators we tried in the past became clogged up or gilled. What we did during this development process was a lot of diving in order to learn how a trawl operates, how the water flows in a trawl, and how the fish and the shrimp react in the trawl. The separator that we have come up with is based on the principle of the difference in the swimming ability and the behavior of the shrimp and the fish.

We put dye in the trawl to see how the water flow comes through a normal Gulf of Mexico shrimp trawl. The fish actively swimming in the trawls slowly fall back into the codend. The water flow in the wings goes directly through the webbing. The only flow you get through the trawl is in the center. There is water flow that goes into the codend but we've measured it with flow meters and found that the flow in the codend is less than the flow on the outside.

We had observed the shrimp behavior prior to this during our electric shrimp trawl work, where we were stimulating shrimp with electrodes to make them jump. We found that the shrimp, at least the penaeid shrimp in the Gulf, react initially with several jumps. They exhibit an escape reaction. Then they are basically carried by the water flow and a lot of them end up in the wings. They are actually impinged on the wing of the trawl, and slowly tumble down into the codend. They are vulnerable to the flow of the water in the trawl. That is where we hit upon the idea of using this difference in the way that the shrimp react in a trawl versus the way the fish react. A shrimp that's lying on the webbing is capable of jumping again, but they seem to become docile when impinged on the webbing.

We also put shrimp into the trawl to see what would happen. In the TED, as they are coming through with the water flow, they are actually just being taken back. The shrimp were alive and very healthy, but they have very little swimming ability or resistance to the water flow.

As we were working earlier with the TED, we noticed that the fish swam in the codend. Particularly in the TED, we noticed they would stream back and then swim forward. There was an area of less water flow to the outside of the TED and the fish would tend to end up in this area. They would actually swim forward in the bag. Of course, the behavior varies for different species. You have all sorts of species, some strong swimmers and some not so strong, and it is a fairly complicated situation. The semi-tropical waters have a tremendous variety of species displaying a variety of different behavioral patterns.

One thing we studied was the area we call the "active zone" of the trawl. That is where the webbing tapers down into the extension area. This is the area where we noticed most of the gilling. It's an area where the fish start exhibiting escape reactions because of the crowding. We looked at improving the water flow in that area to carry the shrimp further into the bag and to create an area of relatively slack water around it. We put a funnel in this area; this actually reduces the area of the trawl at that point and increases the water flow as it goes into the codend. We wanted to increase that flow as much as possible.

We called it a funnel accelerator, and it created an area of slack water around the codend. Water flow there is less than the trawl speed itself. In the middle of the funnel we have about a 20% increase in water flow due to the reduction of that area. This effectively carries the shrimp past the openings, the main reason we put it in there.

We evolved several different designs. What resulted from all this work is what we call a side opening finfish separator. We actually took the webbing, cut it, and moved it in. It serves two purposes: one is to keep the shrimp moving through the trawl, having the effect of another funnel; the other is to guide the fish out. It carries the shrimp back through, and the fish coming up through the bag encounter this panel and swim out of the opening. Again, we are using the water flow difference and the difference in the behavior of the two animals to effect separation.

The initial results with the TED were very good with these finfish separator modifications. We had a 50% separation during the daytime towing. We also put some other openings, called front openings, around the funnel itself. We thought we'd let the fish out that came past the initial panel, but they really didn't seem to improve the separation that much. The main separation effect is from the side panels. We have since eliminated the front openings. We have also experimented with eliminating the funnel using only the side panels as a funnel, because we have had problems with clogging and turtles becoming lodged in it. We are looking at the side panels themselves as the funneling device and have taken the funnel out.

There are several species of fish that swim up from the bag and find the openings, and lead the whole school out. Many fish escape when you haul in the trawl or change the speed.

The hardware itself is not yet perfected. We've made some significant progress in separation, but there are still a lot of things that need to be addressed. We've modified them quite a bit. The original TED was heavy and large. We've made it collapsible, much lighter, and much more useful from the fisherman's viewpoint. Initially, it was a very awkward device to try to use in shrimping.

One of the things we found was a drastic difference in separation rates between day and night. It worked very well in the daytime, but our separation dropped to 10% at night. So we modified it with a finfish deflector. What happens, apparently, is that the reaction is a visual one in the daytime and the fish were getting too far back in the codend and wouldn't come up to the opening. So, we discovered that a grid of stainless steel wire placed behind the device would make a humming noise and also act as a physical stimulus when the fish hit it, causing them to react and go out through the opening. It's rigged with a bungy cord here so that when it builds up with trash, water flow can trip it and clear it out. Since we added that deflector our finfish separation rates are consistently up to as much as 80% in the daytime and 50% at night.

One thing that needs further development is the spacing of the wires. Perhaps there may be even a better stimulus than a deflector to cause these fish to react. We've tried lights and all sorts of different stimuli.

The main point I want to make here is the principle behind this. What is very important is to study the behavior of the animals in the trawl if that is at all possible with the technology we have. You can make significant strides in any piece of gear separator work by knowing the behavior and the performance of the trawl itself.

The principal of the water flow and the difference in the behavior can apply to other types of gear. In our particular application, we have to also get rid of the larger objects, turtles, sharks, etc. So we have the primary grid. I think Phil made an interesting suggestion in his concept of having a panel in front and a secondary separator. That's basically what we have: a grid bar that gets the bigger stuff out initially, so that you can then eliminate the finfish more effectively.

Our work with panels in the past was just not acceptable. We would run into fish of a certain size that would completely gill our panel no matter what mesh size we tried. Our shrimp are much larger and we have a whole variety of fish sizes causing a tremendous problem with gilling. In the Gulf, having the openings and using the water flow has worked much better.

We've looked at a soft model. I think it would work in finfish. Our problem is that we have to get rid of turtles. You've got to have that frame work, some sort of grid. Separators, based on the study of differences in the behavioral reactions in the animal, even modifying the trawls in terms of the water flow characteristics, have a tremendous potential in all of these areas.

Scallops

Dredge Performance and Selectivity

Ron Smolowitz
NMFS Gloucester

What I'm going to try to do is give a general background of the scallop fishery from a gear perspective, and discuss past research that has occured in scallop gear, concentrating on the selectivity aspect. I will also discuss the issue of destructive fishing and other forms of dredge-related mortality. Then I will try to explain the current situation, again from a gear perspective, as far as what's happening in the scallop fishery and in scallop management.

The scallop fishery began after the Civil War, off the coast of Maine. Initially people shucked the scallops, threw the meat away and painted pictures on the shells to sell to tourists in the summertime. But around the late 1880s, they were shucking them, packing them in gallon jars and shipping them to the New York market. One of the interesting things I found in the literature from back then was that they had already figured out how to soak scallops to produce an increase in meat weight. That is all well documented in the 1880s literature.

Very little was known about the scallops. There were problems with species identification. The research ships, the original *Albatross* and the *Fish Hawk*, spent some time documenting the extent of the grounds. The first fishery began in the coves of Maine and it used the old-style oyster dredges. They were towed by oars from pea pod dories. They also developed the anchor seining technique which you hear about in the trawl fishery where the gear was set, the line run out, and then the anchor was run out. The gear was then hauled up against the anchor.

The original gear was built out of flat iron bars about 3 feet long and 9 inches high, of 1-1/2 inch wide by 1-1/4 inch stock, and it came to a bale point. The bag consisted of wire rings on the bottom. The sides and the tops were usually mesh. It was a fairly light piece of gear because you wanted something light for rowing. In addition, scallops were pretty dense back then, but as with most fisheries, the inshore beds started getting overfished and the gear had to move out into deeper water, and new technology started to be applied.

They started using schooners and then steam winches. This allowed for larger and heavier gear. Heavier, not only to stay on the bottom, but also to fish harder bottom. Also, as you move further offshore and you are in a bigger vessel, you need a bigger dredge to meet expenses. This was the evolution of the scallop drag. At the turn of the century, the *Grampus*, another research fisheries vessel, was using beam trawls for the explorations on the shelf and they were discovering scallops up and down the coast from Cape Hatteras up through the Gulf of Maine. You could see the relationship between the beam trawl and the oyster dredges as the best aspects of both pieces of gear started developing into what we now have as the New Bedford-style drag.

A lot has happened this summer over netters coming into the dredge fishery - as if that's something new. Back in 1915, when the U.S. Fish Commission published a pamphlet trying to tell people that there was an extensive scallop resource off the mid-Atlantic, they recommended that the gear to use was a Cape Cod flounder trawl. They recommended that it be made with a shorter bag, heavier twine, and a bar mess of 2-1/2 inches equivalent to 5 inch stretch mesh. They recommended a chain sweep with split links in the foot rope in case they snagged on something, plenty of chafing gear, and that this be towed with a bridle.

The dredges were now getting heavier. They were about 10-12 feet by 1948 when the next major innovation occurred. with the realization that the dredge would fish better if, instead of having the bag attached to the bottom of the drag, you put a sweep chain on it that could follow the contours better. One of the negative aspects of putting a sweep chain on the dredge is that it would tend to catch boulders. That was an anathema until the time when catching rocks in your scallop drag would smash up the scallops. But, the pressure and competition was such that efficiency maximized your catch per unit time. They also added a depresser plate to keep the drag on the bottom so that it could be towed faster. In 1948 it was known as the airplane drag.

In the 1950s, people were starting to get concerned about the possibility of overfishing the resource and harming it. People started asking about what could be done to negate the effects. Ring size was offered at first as a solution, but by the mid 50s, people felt that ring size would not solve the selectivity problem of a scallop drag. There were a number of experiments conducted in Canada and the United States.

In 1952, the legal size was four inches, 100 mm, for a scallop. They wanted to figure out now how to catch less of the prerecruits, the scallops smaller than four inches. The Canadians were using what we call "Digby" style, or rock dredge, the type of dredges that they now fish in Maine. But they fish a number of them from a bar. For the research, they rigged up a bar with five two-foot dredges with different mesh size in each, and they rotated them and fished them for days on the grounds. The problem with a lot of this selectivity work is that you never know what the actual population size structure is in the fishing area.

In this Canadian study they found that with a 2-5/8 ring, all the sublegals and all the legals were retained. That is the base to which the the research was compared . When they went up to a 3 inch ring, 4 out of 10 of the scallops under 4 inches were lost,but all the legals were retained. At 3-1/4, more sub-legals were lost. Finally, at 3-1/2, you start to cut into the legal catch.

This is a fair summary of what most of the gear research, even after this point, has borne out. There's been a lot of discussion about the linkage in scallop drags and whether or not there is there any selection between the rings. There were a number of experiments conducted through the late 50s and early 60s.

One discovery was that the larger mesh drags, similar to larger mesh trawls, brought up less trash. But, again, that wasn't true in all cases. In 1955, Cameron, another Canadian, determined that the efficiency of a scallop drag was about 5%. He was one of the early innovators in using underwater TV. He had a camera sled and he towed it in front of a scallop drag and photographed it in action. One thing he noticed is that in front of the sweep chain, scallops and substrate were bulldozed and swept under the drag rather than into it.

In Ireland around 1955, again, on a different type of scallop, researchers were using tooth dredges very similar to what we call the "dry" or "rocking chair" dredge. In this country and in the clam fishery, for example, we found that the dry dredging has a very low efficiency because of a leaping motion. They found the same results with the scallop tooth dredge. When they put on runners and a depressor plate, they solved the leaping problem, and it brought the Irish dredge up to the level of the New Bedford dredge. They still found low efficiencies, though, and that seems to be the history of scallop dredge work.

Pausegay, an American from Woods Hole, tested 2 inch rings versus 3 inch, 3-1/2 and 4 inch rings, and calculated the percent retention. He found a relationship between the inter-ring space and the scallops retained. He found that a scallop 28 mm smaller than the inter-ring space had a 50% chance of escaping - the so-called 50% selection point. Beard, an English fellow, found out that the depressor plate affected the lift of a dredge and a lot of times you have turnovers with scallop dredges, due to the lift versus drag ratio resulting from the angle of attack of the depressor plate.

In 1960, another Canadian studied 3 inch versus 4 inch rings and various linkages, and found a 10% increase in efficiency of the market size scallop and a decrease in the catch of trash and undersized scallops. They concluded, in 1960, that going to a 4 inch ring wouldn't work because it wasn't large enough. Today, of course, the situation is different. If you went to a 4 inch ring, the catch would decrease tremendously.

In 1962, with a New Bedford-style drag, they found a 4 inch ring bag had the same escapement rate, but it retained 100% more than did the 3 inch ring bag on scallops 4 inches and larger. In other words, the efficiency of the legal size scallops increased with the 4 inch ring compared to the 3 inch ring. This is something that we have seen in lobster trap work and something that we have seen in trawl mesh codend studies. There is an increased efficiency of the larger size animals. Among a lobster trap, an otter trawl and a scallop drag, there are probably three different reasons for this.

When we talk about the rings, you can see that the inter-ring space is larger with a single linkage. If you increased the linkage to double links, triple links, or 5 links in some instances, you'd tremendously decrease that inter-ring space. In Figure 2, the lower graph shows the lower line for 3 inch rings and the upper line for 4 rings, versus the number of links in the inter-ring space. With a single-linked, 3 inch ring you have about 100 mm or 4 inches of space between the rings. But if you bring that down to 4 links, you are down to under 3 inches, and the inter-ring space is now smaller than the rings. So, if we do any sort of selection work with scallop drags, we have to be concerned about the inter-ring space, as well as the rings themselves.

Some studies done by Metcalf & Born in 1964 found a number of possible sources of mortality and indicated that in soft bottom, drags may force mud into scallops, killing them. Drags may also reduce the settlement of scallops or even cause anaerobic conditions, which may kill any scallop present. Hard bottom scallops may be mechanically damaged as the drag rides over them. Undersized scallops retained in the drag are subject to mechanical damage and probably psychological damage in the boarding, dumping, culling, and shoveling operation. They established a 15% mortality rate on the discards during that series of experiments.

The conclusion of a number of the gear researchers was that if we are going to develop size selective gear, we had to start from scratch. For example, we want to keep all the scallops that are 3-1/2 inches but we want to get rid of all of the scallops that are 3 inches. We are trying to sort scallops over a range of a 1/2 inch with a piece of gear that has very poor mechanical selection.

At the present time, the general conclusion is that the selectivity of conventional scallop drags with a ring bag dragged along the bottom is not sharp enough for management purposes. A whole new piece of gear has to be designed. NMFS started looking at scallop gear design options; we met with fishermen and received several dozen suggestions on how to improve selectivity of scallop gear. We've never been funded to conduct any of the experiments needed to design new pieces of gear and that's where we are today. Some of the suggestions include: getting the bag off the bottom by putting it up on runners, instead of using rings; to use something like a square mesh grid; or to use fixed cage drags as they do in Australia.

Age, to the side, is versus maximum yield per recruit, where the scallop year class production of meat is maximized versus its natural mortality. In other words, it's where they keep on growing faster than the natural mortality that is killing off meat weight. Ideally, you want to harvest scallops up around 5 or 6 inches. We are nowhere near that point and are harvesting around 3 inches. If instead of harvesting all the scallops at 3 years old, you waited one more year, you would have doubled the total meat yield of that scallop year class. That is one of the goals. We have to try to increase the size of the scallop we are harvesting, but we can't do it all of a sudden. If we put in a 4 inch ring today, the catch would drop drastically because there are very few scallops out there. It's a question of how to get there from here.

A recent experiment was conducted on a New Bedford dragger using S-K funds, and it showed the catch rate between a regular, 3 inch ring multi-link chafing gear and a 3-1/2 ring. The larger ring size allowed a lot of the smaller scallops to escape. For example, with the 75-70 mm class you catch 14 scallops under 3 inches with the 3-1/2 rings, versus 132 scallops under 3 inches with the conventional gear. If you go to the 4 inch and greater, you see there is an increased efficiency of the larger gear on the scallops. The 3-1/2 inch ring caught 628 scallops versus 496 scallops in the smaller ring size. The problem occurs in the bracket between 3 and 4 inches. You lose marketable catch at this point in time. Your selection doesn't change to the point where the increased efficiency of the larger gear compensates for the loss of catch due to selection out of the scallops runnings in the 85 to 95 mm bracket.

To tell you the truth, I don't know if we could ever get selection that sharp. In theory, if you look at this altruistically and you don't have to make your living from it, you see that New Bedford would be better off if the scallops were harvested at a larger size. If you did harvest scallops at 5 inches or larger, and you did put in a 4 inch ring, and you had a number of year classes there, you'd have virtually no mortality on these smaller year classes that are two or three years away from getting into the fishery, compared to trying to harvest all the legal size or market size. The market will buy 50 count scallops.

A quick experiment we did compared an unlined, 2 inch ring dredge versus a trawl that had a 1-3/8 inch liner. The trawl had a 25 foot footrope, possibly a 16 foot spread with a bridle. This was just a quick three tow experiment in three different areas. In the first case, without any legs on a trawl, we caught 700 scallops in the lined dredge, versus 470 in the unlined dredge, and in the trawl we caught 850 scallops.

In the next experiment we increased the weight of the trawl's sweep chain, and the lined dredge caught 216 and the trawl caught 729, a big improvement in the efficiency. In the third experiment, we dropped the speed down from 3-1/2 to about 2-1/2 knots and caught 110 in the dredge, versus 510, in the trawl. The trawl was about twice as effective in catching small scallops, but the drag caught larger scallops. This is preliminary data. I think Phil Cahill has some more recent work.

One thing about selectivity that needs to be explained is how one calculates the percentage of retention. There's half a dozen different ways to do trawl selection or scallop gear selection work. The trouser trawl was one of the earlier methods tried, and was discredited early on because it was found that if you fished the trouser trawl with two parallel codends, even if you fished the same mesh size, you'd get a different catch in the different codends for reasons that couldn't be explained. The next methodology that was developed was what was called a "covered codend" method. Here, you would put a cover over the piece of gear of a much smaller mesh size than the codend or the ring bag that you would be testing. Then, whatever passed through that codend or ring bag would be held in the cover, and you would take the total catch of codend and cover and that would be what you'd say the population was. You'd then compare that with the catch from the codend so you'd get a percent retained. The maximum you could get would be 100%. But covers have a masking effect. They screw up the gear by affecting the water flow.

Scallop management now is by meat count system. Right now it's a 30 average. The fishermen say they don't like that. There're many problems with measuring and we'd like to see a gear regulation in effect. We are now at time where we are supposed to be going out with some fishermen to test some ring sizes again and see what benefits are going to happen by decreasing the mortality. Most of the fishermen with whom we are dealing understand that gear cannot be the complete management program and alternate measures must be taken.

Trawling for Scallops

Phil Cahill
Maine Dept. of Marine Resources

In the mid Atlantic there's been some concern about the scallop management plan, and the question that seems to be most prominent down there is about the effects of trawling for scallops. The effect of this fishery on the industry is usually short term, two or three months out of the year, and the resulting 50 meat counts have become acceptable to the markets.

VIMS was asked by the East Coast Fishermen's Association if we would take two vessels, one equipped with conventional 15 foot New Bedford dredges, and tow them through a juvenile population with a boat alongside with a double rig gear. We used a 90 dog net with 4 inch mesh up in the fore part and a 3 inch codend. We did this and gathered some data over a 24 hour period.

Kenny Daniels, from Wanchese, donated the use of his boat. There was no money provided by S-K or anybody else. The Fishermen provided this and we towed a double rig off Frank Peabody's boat out from Cape May.

We counted about 50 boats in the area and we were within 200 or 300 yards of Benny Rose's boat, towing side by side. We were about 8 hours out of Cape May. The vessel was 75 foot and she had 450 horsepower.

What concerned us was the amount of juvenile scallops that we hauled. We found that there was no mortality in the trawl. Most of the scallops were in good shape when they came up. The majority of the damage occurred when the catch was dropped on deck and when people had to walk across it.

We have two forms of fishing down in the mid-Atlantic. One form brings the scallops aboard, shovels them down below, ices them down, and brings them in to be shucked. The fishermen claim that they take the scallops and put them up against a 2 by 4, and all those that don't make the edge of the 2 by 4 go overboard. The other method is to simply lay-to and shuck. We found that we averaged 55 meats per pound trawling for scallops, and the dredge boat working alongside of us averaged 24 meats per pound.

The question the fishermen have is, What is the gear selectivity solution for this? To find the answer, we took the baskets and measured 3,000 scallops by hand. The results showed that the average scallop had a 52 meat count. In approximately two hours and 20 minutes, we took 8,100 pounds of scallops.

We found 52% of the scallops were below 3-1/4 inches. On the dredge, 35% of the scallops were below that. Everything on the dredge was able to be discarded, but it's physically impossible to effectively sort the volume caught by these trawls.

Another more significant problem was that the meat count in the shell-stocked scallops was higher. This could occur because the ratio of meat to shell size isn't quite accurate, so that the people shucking at sea are at a disadvantage compared to the people shucking ashore. A 3-1/4 inch scallop that can be brought ashore might give a 40 or a 42 meat count.

There are a number of considerations that need to be made. Many boats in Carolina run into a dead period between the shrimp seasons in Pamlico Sound and this is a cheap alternative for them. They don't have to be equipped to handle dredges. They don't need the big crews. They bring them in and sell them to the local calico scallop plants. The net we used was 87 foot on the footrope and it's the same gear that they use to go fluking. There is no change for them. They can get into this fishery with a minimum amount of investment.

In 1960, we had approximately 100 boats harvesting 26 million pounds of scallops. In 1985 we had 313 that harvested 42% less than that. If you look at this and consider the implications on the stock, it's pretty serious. Then you add another 100 to 200 boats from North Carolina, South Carolina, and Georgia that are not generally in the fishery. This creates a problem that we don't know how to solve. It is a management nightmare. You are going to impact an economic group if you stop it.

In a typical trip, they can catch 20,000 pounds or more shell stock. Some of the boats will do 45,000 pounds. They'll bring them to the dock and take them off there. Most of them are dead in spite of the fact that they are iced down.

A group of fishermen from Cape May, Norfolk, in conjunction with the Newport News, went to Mr. Calio's office and asked to have a ban on trawling for scallops. Because of the sensitivity, they went to the management meeting, and the management people said they would look at it. We proposed that the only way to take scallops was with a dredge, which would force everybody to play by the same rules. We would welcome any suggestions from anybody. In our area of the country, this is a profound problem in a fishery that is already economically depressed.

Question, Kathy Dykstra: Was that worth it? If people are fishing like that, they must be making money or they wouldn't be fishing like that. If they aren't making money, why on earth would anybody be doing that?

Phil Cahill: They are all good scallops because you are bringing them to the dock shell stock.

Question, Kathy Dykstra: Are they not illegal under the current management plan?

Phil Cahill: Under the management plan they are illegal. This is more of an enforcement problem.

Question, Kathy Dykstra: What you are saying is that if this law were enforced you would not have a problem.

Phil Cahill: If the law was enforced you would have less of a problem. However, it would be as impossible to enforce the law completely as it is trying to enforce the law on codend liners.

Question, Kathy Dykstra: If someone had a suggestion for a better way to go about it and it was not enforced, that would be no more effective than the current situation. What is needed is a way to enforce what we put into effect no matter what it is.

Phil Cahill: I agree with you 100 percent. I would think the only justifiable solution would be to ban the netting of scallops and make everybody take them with a dredge. If you wanted to get into the industry, you'd be making the economic contribution. Again, it becomes an enforcement issue. I think that maybe the enforcement people can tell us of the problems that they have. I know they have budget constraints and not enough people, particularly in our area. If you've been to North Carolina, there is a myriad of spots where you can go and put your scallops into a truck and they're gone.

Cage Drags

Phil Averill
Maine Dept. of Marine Resources

In Maine, we have an inshore scallop fishery using both rock drags similar to a Digby drag, and an increasing number of New Bedford drags. We are going through a management turnover in the scallop fishery and are in the middle of a series of annual regulations that gradually decrease the size of the drags. The selectivity issue hasn't come up from an enforcement point of view, since we have the same regulations as the federal government. Where the selectivity issue has come in is in the effect of the gear on the bottom and the effect of the gear on unharvested scallops.

We have been looking at both mussel drags and scallop drags. We have a very large mussel fishery in Maine that has increased a great deal over the past five years. The number of conflicts that have occurred in the mussel fishery has prompted us to look at mussel drags and their effect on the mud itself, the animals that live in the mud, and the unharvested mussels. This work has also moved over into the scallop fishery. If we look at scallop selectivity, what we are primarily looking at is the release of unharvested juveniles in good condition, and the reduction in the impact of drags on the very young year sets.

The most recent step taken was a result of the March meeting of the Undersea Research Program, the National Marine Fisheries Service and DMR. We put TV cameras on some scallop drags and chased lobsters for a couple of weeks. This was just the preliminary work for a longer-term project. We will be continuing this work, now that we know that we can get cameras on those drags as well as on the bottom. We are learning more about good places to work up there, and there will be more intensive work in the future.

We have tried to address the issues of one, the effects of scallop drags on lobsters; two, the effects of scallop drags on juvenile scallops; and three, the effect of scallop drags on unharvested scallops. A number of studies have demonstrated that scallop drags are only 5-10% efficient. That is, if there are 100 scallops in front of the drag, you are only going to pick up 5 or 10 of them. That means that the drags are going to run over the other 90-95 of them. Most of these scallops are down in depressions, and the drag goes right over the top. There will be some scallops impacted by the drag. The number usually isn't too bad. If the cutter bar hits them or the sweep chain hits them, those numbers aren't too bad either. But if you've got 6 or 7 feet of ring bag full of rocks and scallops, which can weigh a thousand pounds or more, pounding over that scallop, that's going to have an effect. It seemed to us that the bag was doing the damage rather than the cutter bar or the sweep chain.

We then looked at cage drags, which have been around for a long time. Europeans have used them. The Australians have a whole fishery based on a cage drag that has a cage that rides on skis, instead of a ring bag. There is a space between the cage and the bottom and the skis take the weight off the drag. Will these work in a commercial fishery? Will these work on the hard bottom in Maine? That is why we use rock drags, to work rocks up there. The rock bound coast of Maine does continue underwater.

There is no way you could put an 18 feet cage drag down and expect it to work. Ganging up 7 or 8 two footer rock drags is a possibility, but that has its own problems. Now that we're getting down to the 8, 10, and 12 foot range limitation, it becomes a little more practical to look at cage drags. We have built a cage drag, we've towed it, and we've put divers on it. We've tried to put TV cameras on it, but we are still perfecting that system. Our work came to a halt at the end of scallop season, and we are not going to get back to it this year. So, we have a 4 foot cage drag we'd like to have used. It's a little different up forward, but we can easily convert it into a chain sweep.

We would be more than happy to cooperate with anybody who has the time to tow it. We have no concerted effort planned for this year. I had hoped to have more results at this meeting today. I think cages in both the mussel and scallop fisheries could be helpful because of the impact of gear on the bottom issue and the fact that you can control the mesh size better than with rings. You can use alternating bars on the bottom of a cage drag, similar to what they are using in some of the quahog dredges, that better sift out the rocks and the small scallops.

Cage drags open up many possibilities in the areas of controlled size and refined selection. I don't know if we can get down to Ron's half inch tolerance, but we can come a lot closer than we are now. Cage drags get away from ring bags; plus, they are easy to handle, lighter, safer on deck, and much less expensive to operate. I myself am excited about cage drags. They have been used in many parts of the world and I think they are something we should get into.

Pelagic Stocks

Overview

Guy Marchesseault
New England Fisheries Management Council

Although we are calling them pelagic fisheries, I think that the problem is better defined as off-bottom fisheries. I think that the truly pelagic species are not the problem as far as we're concerned, but rather it's the species that are off the bottom that pose the problem.

For those of you who are not familiar with the problem, I would like to put it into context. This is part of the multi-species fishery which is the major fishery under management in the New England area. The multi-species fishery is essentially a trawl fishery that depends on a number of species. We take a different approach in this fishery than to any other that I can think of. This is not a multiple-species management plan; we're not trying to manage a fixed number of species. Rather, we are trying to manage a fishery. One of the most important attributes of our fishery is that it is a historic groundfish fishery that has focused on flounder, cod, and haddock species. Among the flounders, yellowtail flounder is the one with which people are most familiar. Yet, there is another entire dimension to the fishery that is really the alternative side of the fishery. It's the part that concentrates on species such as whiting, butterfish, shrimp, squid, scup, and others. These are the species that are the reasonable alternatives. They are the species that generate a tremendous amount of money and, in many cases, have to be conducted coincidentally with these fisheries for cod, haddock, and yellowtail.

In my opinion, the biggest mistake you can make is to put on blinders by trying to manage cod, haddock, and yellowtail without recognizing the impact that a certain type of gear might have on another species, particularly the legitimate small mesh species. By and large, we specify that, in this general area shown in Figure 1, we have a relatively homogeneous interest in the larger mesh species such as cod, haddock, and pollock, and that interest extends into the coastal waters. In addition, you have a very legitimate interest in species such as whiting and squid, which are species that have to be conducted with small mesh, yet are species that can have a deleterious effect on the regulated large mesh species of which we are the most cautious, from a management perspective.

Consequently, the management plan restricts the use of small mesh to a small area, as well as on a seasonal basis. We do have what is called the Exempted Fisheries Program in which you can enter that fishery and fish legitimately with small mesh gear, but your by-catch of the regulated species is very tightly controlled by a reporting system. That by-catch is limited to about 10% over a 30 day reporting period. That is 10% of the regulated large mesh species which includes, at the moment, four species of flounder including grey sole, dab, blackback, and yellowtail, in addition to cod, haddock, and pollock.

Figure 2 shows the relative frequency of trips on which mackerel were caught. The cross-hatched bars indicate trips on which mackerel was less than 50% of the catch. So you wouldn't call those directed trips for mackerel. When you look at the trawl gear, the one that is of potential concern to me, it becomes pretty clear that this is not a directed fishery. It's really a by-catch fishery for mackerel. It may very well be that it wouldn't be the gear choice for mackerel in the Gulf of Maine, and as a consequence, it may not be particularly problematic in its position with trawl fishery for the regulated species. What it does say, by and large, is that we will not make a special exception for a trawl fishery for mackerel in the Gulf of Maine. If it is caught in the Gulf of Maine, it ought to be caught by one of the other gear types. The whiting fishery in the Gulf of Maine (Figure 3), however, may be more problematic because trawlers are principally responsible for whiting catch.

Right now the regulations allow for a fishery of herring, mackerel, and squid on Georges Bank as long as a midwater trawl is used. There has been considerable discussion about what a midwater trawl is, due to the definition in the foreign fishing regs. However, the current regulation, for ground fish or multi-species, is that no portion of a midwater trawl can come into contact with the bottom at any time. That doesn't seem like a very satisfactory definition to me because it does not allow for that gear to consistently fish for the alternative species with minimum by-catch of the regulated species. I think that the challenge posed for us in gear research is to make sure that it's possible to allow legitimate small mesh fisheries to be conducted coincidentally with the regulated large mesh species.

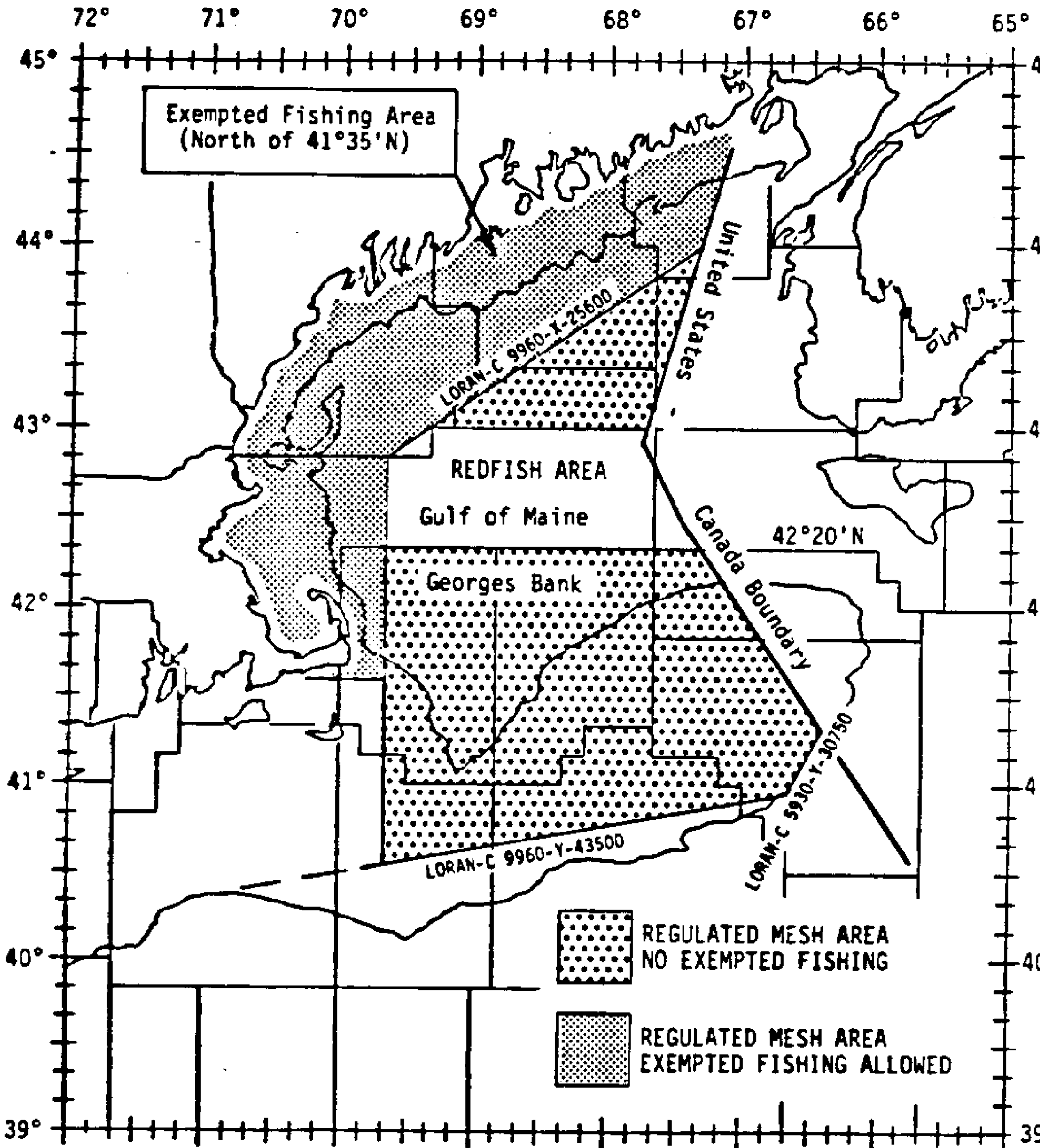


Figure 1. Fishing Areas of the Northeast

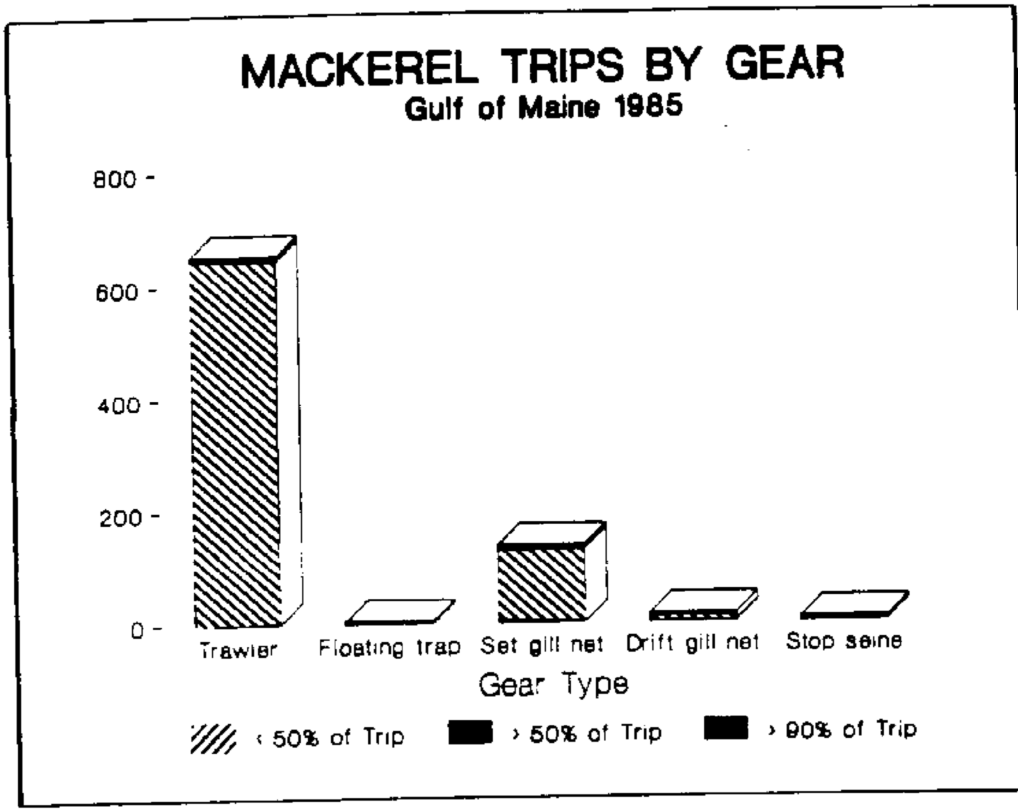


Figure 2

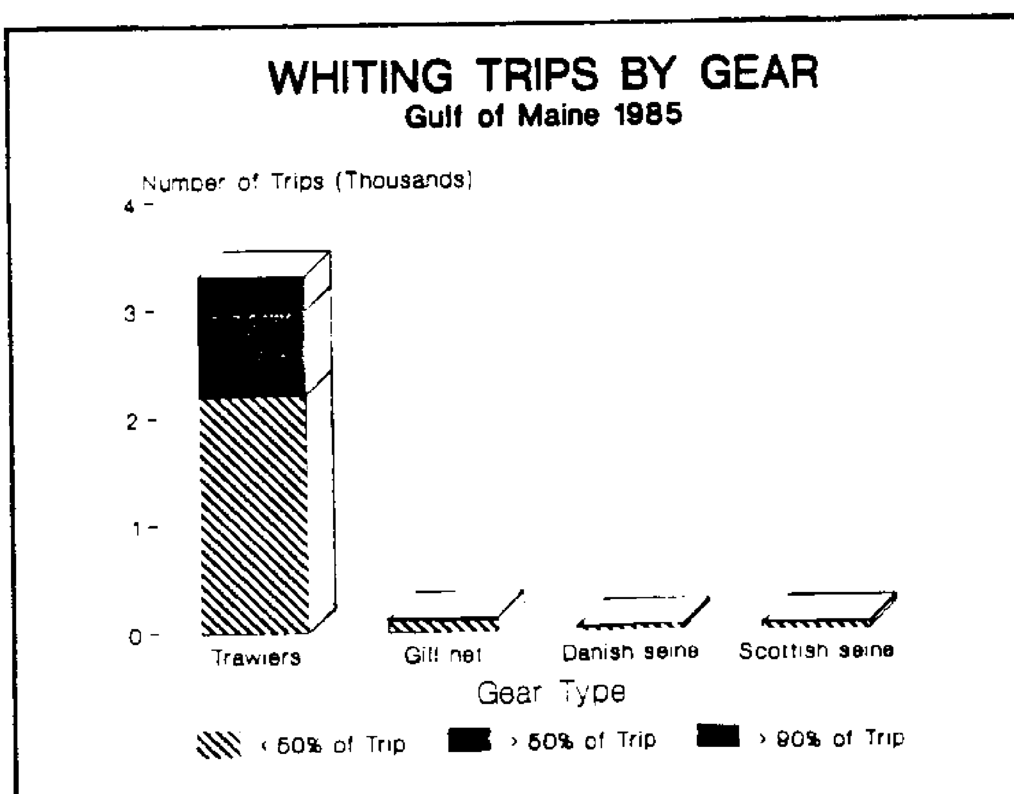


Figure 3

Observations of Gulf of Mexico Pelagics

John Watson
NMFS Pascagoula Laboratory

The Southeast Fisheries Center has started a project in an attempt to sample and harvest what we suspect is a vast resource of coastal pelagics in the Gulf of Mexico currently unharvested. We are approaching it by looking at gear and fish behavior using several techniques. We started on the project with the transfer of a stern trawler from the Northwest, the RV Chapman, a 127 foot stern trawler. The first thing we did was start looking at gear that is available now.

There have been few attempts at trawling a complex of coastal pelagics, consisting of about 15 species that include butterfish and squid, in the Gulf. The problem is that these fish are very fast swimmers and the water is very clear. Most of the attempts at trawling for these fish in the past have been unsuccessful. The Russians and several U.S. commercial groups have tried.

One significant and important breakthrough the first year was to learn something about the behavior of these fish. Initially, we used divers to look at several different types of gear trawl designs. The most promising one, which we are using now, is a trawl designed by Paul Shuman that uses a net we first saw in the NSRDC test tank. We've been very successful at sampling these fish with this trawl. The way we are able to capture them is through a tactical change in the way we fish.

We also have the MANTA system and it has been quite successful. We've had growing pains, but we think its a viable system for our work, particularly in the Gulf. The launching problem was solved with Bertha. It's a zodiac with a cut-out stern. We did have some video camera problems, among other problems, but we've made good progress. We are starting sea trials next week and we feel that the system will answer a lot of questions. It will extend our ability to look at fish behavior and trawl gear more deeply than we can with divers.

We designed and built a trawl ourselves. It provides an interesting comparison due to its fairly fast tapers and very large volume. It has a long extension and a very large volume in the codend, which turned out to have an interesting effect on the way the fish react in comparison to the Shuman trawl.

Where depths permit, we can look at the gear configuration noting spread and heights at different speeds. In the process, we are able to observe fish behavior. Our problem in the Gulf is the difficulty of catching these fish. They get in the net, but then all of them get out again. One of the interesting things we've found is that the fish school in the trawl. With this large-volume trawl there is very little water flow. In fact, there actually is a circular pattern to the water flow in the codend and the fish basically can rest there for the whole tow, and then, when you haul back, they swim out the front.

Another thing we've noticed during our diving is that the squid tire very quickly. Typically, they come into the trawl and swim from one side panel to the other, tire extremely quickly, and are just swept back into the codend. We've never seen them charge the netting, even in the Shuman net which has a 32 inch mesh.

The point is that you need to know the behavior of the animals just as we did in our previous efforts with the shrimp trawls. There are ways to separate these organisms, either by getting rid of them or keeping them, but first you have to know their basic reactions. Then you have to know what the trawl is doing, what its configuration is, and what the water flow patterns are. What we found out was that if we provided a resting place for fish, they left when we went to haul back.

What happened with the Shuman trawl is quite different. It tapers differently and has much more water flow in the codend. The fish must work much harder to keep pace with the trawl, and they tire as a result.

An interesting thing we learned was that to capture these fish, the haul back process was critical. We had to do two things. One is to wash the fish down. Fish reacted to a change in the trawl speed. As long as you were going at a steady sustained speed, they seemed happy. As you haul back, they have to swim very hard again the 4 knot towing speed. As we hauled in, the net starts collapsing and webbing moves in on the fish. If you haul back slowly, that's when they take off. The fish can swim all the way up to the front of the net and out the mouth.

When the large-volume trawl collapses, it leaves very big openings and pockets whereas the larger mesh Shuman trawl collapses as a uniform sheet. It collapses horizontally, maintaining its vertical opening, and it collapses quickly, trapping the fish in the small mesh, enabling us to catch them. This was strictly due to the way it collapses during haul back.

Another thing we did was institute a washdown process during haul back where we actually tow the net for 7 or 8 knots for 30 minutes; after the doors are up, this washes the fish back into the small mesh and we are able to keep them. We've made 30 minute tows of 10,000 pounds or better. These tows are the best catches of these fish that have been made in the Gulf and it's strictly due to our observations on what the fish are doing. We think we can improve that quite a bit. We are now looking at a fish flap type device to try to keep these fish back in the small mesh. Paul Shuman has included one in the latest trawl he has provided us.

These observations are very interesting to me. I think we need to learn a lot more about what the fish are doing in the trawl and what the trawls do. We can then answer a lot of the questions about productivity and selectivity.

Regional Gear Observation Project

Cliff Goudey
MIT Center for Fisheries Engineering Research

According to the people who are in the business of designing or building nets, we are able to study the designs of nets and their geometric performance very effectively at the tow tank. Today, if someone can state what shape net he wants, it can be designed, and using the tank, we can verify its performance. If we do enough of this sort of tank testing and combine that with some knowledge that we can glean from tank tests done in other places, I think we will eventually be able to design nets and have predictable performance, and the process of tank testing will become obsolete. However, we're years away from that and there remains a big gap in our knowledge. Until we understand how fish are going to be reacting to the net, we really can't make much progress. That's been a frustration for me. The videos, which a lot of us have seen from the Marine Laboratory in Aberdeen, certainly have made me wish that we could do something similar.

While I have a great deal of respect for the Aberdeen Laboratories, I'm not sure how much their results can apply to our fisheries. Conditions are very different over there. The water temperature and bottom conditions are different. The species may be the same if you look them up in a handbook, but I suspect that their behavior would vary from what we might see. Some of the results seen on the video tapes from other parts of the world must be taken with a grain of salt. The other big difference is that their gear is different, not only the mesh size, but the shapes of the nets. Almost universally, the type of gear that research institutions are using is quite different from the gear that fishermen are using. Some of that difference is logical and easily understood. Other differences come about because fishermen have adjusted their gear to perform a different purpose than gear researchers might.

As a result, if we want something done that is going to apply to our fisheries, we probably have to do it ourselves, and that leaves us with the problem of not having the necessary equipment. While something has got to be done, MIT Sea Grant does not have the financial resources to develop or purchase a system alone, nor do I think we have enough active research applications to really justify having a system to call our very own. There are a lot of organizations with gear research interests in this region and all of them would benefit from having a system that was available. That's one of the differences between this region and Aberdeen or down in the Gulf area, where the National Marine Fisheries has a very well-funded program in gear research. So the concept of buying a system for regional use came to mind and was suggested almost a year ago to a group of people who got together at MIT. Out of that meeting came a whole shopping list of project ideas that would benefit from the existence of a regional towed observation system. That concensus seemed to be a sufficient catalyst, and we submitted a proposal for S-K funding to buy a suitable system. We decided that the quickest way to establish the needed capability was to purchase a commercially available system.

The system, which Aberdeen developed, is being commercially built by two companies, both from Scotland. These two companies are competitive, but their products look identical from a distance. As seen in Figure 1, the maneuvering of the vehicle is done be spinning rotors that produce a side force and, depending on the direction, the horizontal rotors either depress the vehicle or raise it, and the vertical rotors can move the vehicle from side to side.

It does take a lot of power to drive the rotors, and because of this, the umbilical on these systems is about 1-1/4 inches in diameter. This produces quite a bit of drag, therefore the vehicle has to be even bigger, requiring even more power. It's a "Catch 22." All they are trying to do is get this camera down somewhere near the net and yet you have a vehicle that is 7 feet high and 7 feet wide. It's not that heavy because it's only a framework but it does have to be manhandled aboard. The winch size required to hold enough 1-1/4 inch umbilical would dwarf a lot of vessels.

Another system is the Manta vehicle by Sea-1 Research in British Columbia, Canada. The Manta was developed primarily as a surveying system with side scan sonar and a few other sensors. There are computer controls and its flight is very stable. It's a smaller unit than the rotor type and Figure 2 shows the version that the Pascagoula Laboratory bought.

In an earlier version the camera was mounted on top behind the towing frame. The newer version has the camera in a belly turret underneath the vehicle. With this, they can look forward, back, or to the side. It is 8 feet long and, because the unit is self-powered and has batteries onboard, it doesn't need the kind of cable that the Scottish system does. The tow cable has four small conductors and is Kevlar reinforced and the winch is quite small.

The entry price to purchase the Manta system is \$200,000, and that was what we based our proposal on. Had we been successful in getting that amount of money, we'd be in the business of doing the final negotiations with them. Unfortunately, we didn't get all the money required. Instead, we were awarded half of what we needed.

We considered the idea of leasing a system. The main problem with leasing was that there was no guarantee that we would ever get sufficient funds to do this sort of work again. As Bill West explained and John Waston has agreed, there is quite a learning process involved in operating such a system. If we had a 6 or 8 month lease, we would probably just about be proficient when we had to send it back. In order to satisfy our financial constraints, the approach we are taking is to look at something other than the systems I've mentioned, and by combining some existing hardware that has been demonstrated for other purposes, assemble a lower cost system.

The oil industry has been quite a supporter of companies in the business of making underwater vehicles. The prime market for the Scottish system has been the oil industry. The oil industry is now depressed, so many of these companies are looking for other markets. The fishing industry is a natural market, but we're not used to spending the kinds of dollars that the oil industry can afford.

The job of inspecting underwater platforms or surveying pipelines can be done by some pretty inexpensive vehicles. One of them is made right here in Massachusetts by Deep Sea Systems International and is called the Minirover. It's very easy to operate and is an economical system. The problem is that it doesn't lend itself to observing trawls. However, the underwater housing, the camera, the pan and tilt mechanisms, and all the controls are all applicable, and all that is needed is some way of maneuvering it in and around the trawl.

The approach that we are planning is shown in Figure 3. The delta wing shaped body is something that oceanographers have been using for a long time. It is made by ENDECO, a company in Marion, Massachusetts. It's called a V-fin, and they use that to take temperature probes or salinity probes to full ocean depths without using a lot of wire. It's used a depressor. With the addition of some control tabs, this can be maneuvered up and down. This has been done for some applications where they want to take temperature profiles up and down throughout the water column. What we've done here is added the canister of the Minirover.

The V-fin has been demonstrated to be stable and maneuverable with a variety of pods attached to it. In our case we will have the ability to have a camera at both ends of the canister for viewing both fore and aft.

For fisheries applications, both the Aberdeen system and the Manta system rely heavily on the use of an intensified camera. In at least half of our work that will be essential. We can't be down there with glaring lights and expect fish to react in a characteristic way.

We should be able to accomplish the assembly of this system within the same time frame we were planning had we bought the Manta. We're not really developing any new systems; we are only adapting already proven hardware and that is going to be the secret of achieving low cost. Both of the companies are very anxious to participate, and while we will be buying the systems, they are going to be providing the engineering expertise to link the two together. They are looking at potential markets for these systems so they have a stake in seeing that the system works. With that sort of cooperation we can do this well within the budget that we've been allowed.

Again, we have a whole list of projects that need the use of the system. We only have one year of funding, so we must prioritize that list and hope there will be opportunities for follow-on funding to make sure the system remains operational.

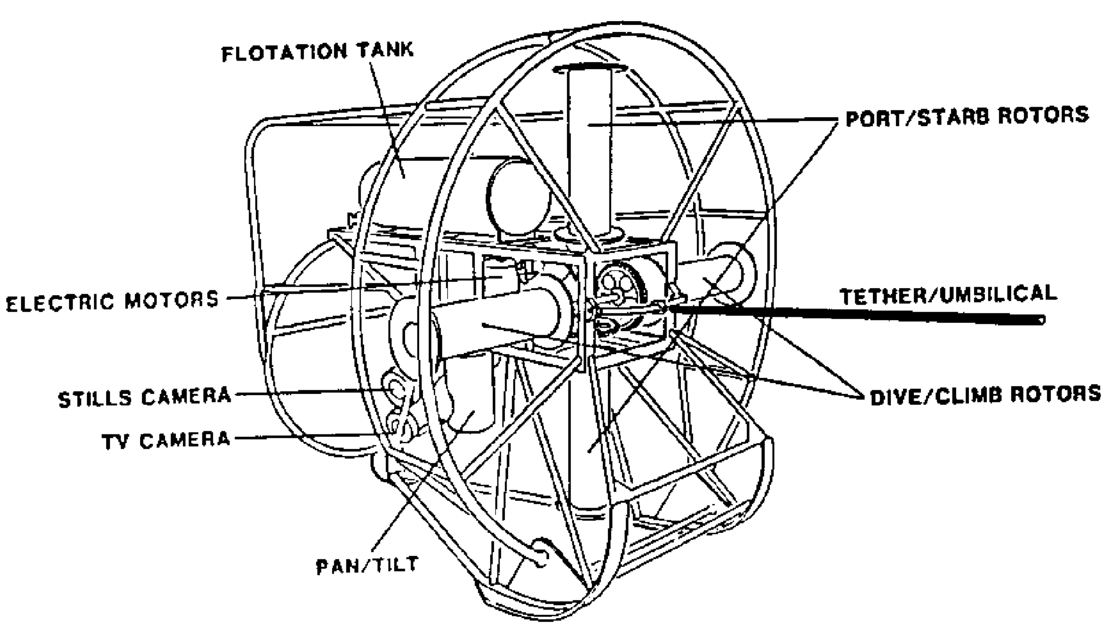


Figure 1. The DAFS-developed towed rotor observation vehicle

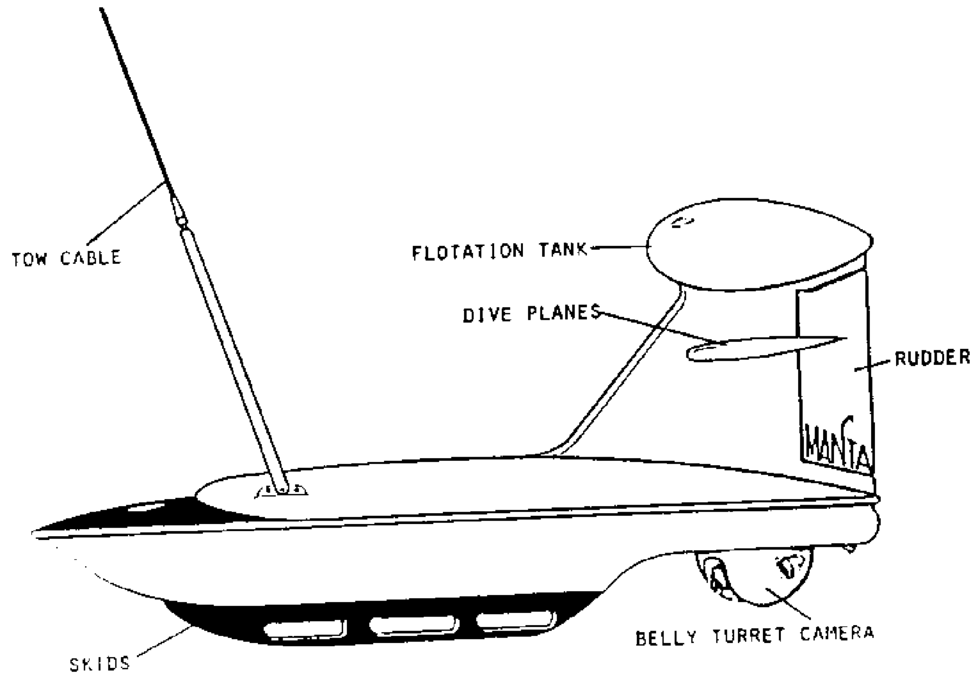


Figure 2. The Manta II from Sea1 Research

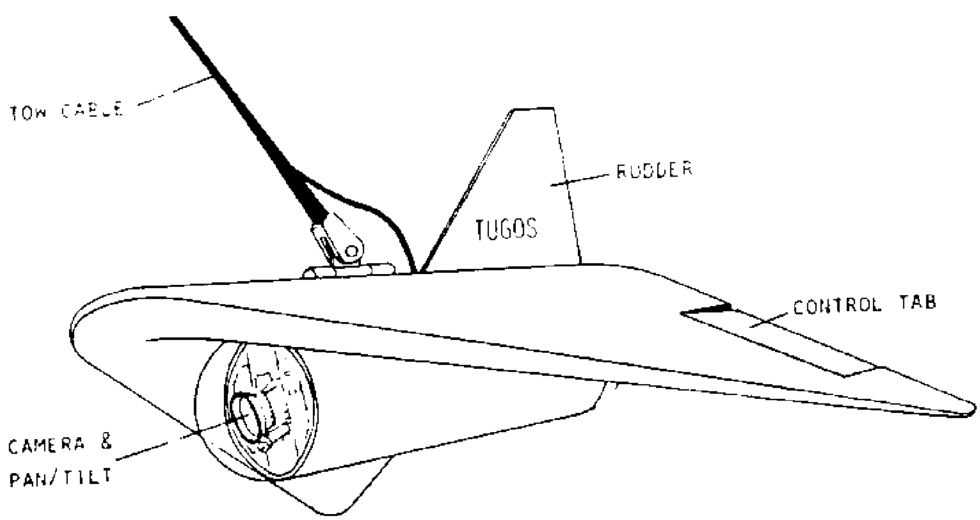


Figure 3. A preliminary drawing of TUGOS

Informational Needs of the Management Council

Guy Marchesseault
New England Fisheries Management Council

First of all, let's go back a little bit so that we can understand the council's goals and what the Council is attempting to do. We hope you will then understand why gear research plays such an important part in the overall planning of the Fishery Management Council.

The first thing to understand is that anyone in fishery management must always relate their work to a biological standard. When you talk about managing any fishery resource, particularly in the kind of management we do under the terms of the Magnuson Fishery Conservation and Management Act, you must always ask how any particular management actions relate to the inherent basic productivity of the fishery resource. What we know about fisheries populations, for example, is quite straightforward. There isn't much mystery involved in the biological systems that are associates with fisheries.

Figure 1 illustrates the decline in the numbers of a cohort, beginning at age 0 with relatively high numbers, which then decline through natural causes until the population gets to be 10 years of age. I have illustrated a fairly precipitous decline, which is consistent with natural mortality at about 18% per year.

At some point in time in the natural decline of a cohort, we commence fishing mortality. When that fishing mortality begins, whether it be at age 0 or 2 or 3, plays a major role in the total productivity of the resource over time. In Figure 1, I've also illustrated tow fishing strategies. One line illustrates commencement of fishing at age 2, and the other line illustrates commencement of fishing at age 3. You can see that if you start fishing at age 2, you can only tolerate about half the fishing mortality as you could as if you started at age 3 and still generate the same decline in population.

The point here is that in a fishery such as we have today, one that is already heavily exploited, one of the most powerful ways to compensate for effort is by controlling age-at-entry.

Figure 2 is an example of the kind of analysis referred to as the "biological paradigm." It is, in fact, a yield-per-recruit analysis. Once again, this illustrates the fact that if you're concerned about yield-per-recruit, you have to take into consideration that at various times in its life, a cohort is going to be more, or less, productive. A fish is going to grow more, for example, when it's two or three than at other times in its life. Populations typically start off growing rather slowly, then increase their yield very significantly as they grow a bit older. Later, as the populations become more or less senescent, the potential yield falls off.

One line shows you the maximum yield-per-recruit that you can get if you start fishing the population at age 2. Also shown are yield-per-recruit isopleths at age 3, and at age 4. The interesting point about this is that very often people will advise that fishing your resource at F max, the maximum point on the curve on this yield-per-recruit, is all that resource can stand. This figure suggests that by controlling the age-at-entry, one has great control over the ultimate productivity of the fishery resource.

It is clear that, under prevailing conditions, the fisheries that reflect fishing mortality rates of .8, .9, or 1 are getting to be more and more common. That is a fairly intense level of fishing mortality. Fishing mortality rates used to be considerably lower, e.g., .2, .3, or .4. When you combine all sources of mortality, you end up with a total mortality rate of .7 or .8, which corresponds to over 50% reduction each year. So, under the conditions where a fishery can generate that level of fishing mortality, one of the most powerful strategies is to increase the age-at-entry.

However, in fishery management, the ultimate goal is to ensure the ability of that population to replace itself over the long term, or to continue to generate progeny that will replace the population. If you are fishing in excess of the ability of the resource to replace itself, all you can hope for is a decline in the population. If you are fishing less than the ability of the resource to replace itself, then you end up with a population growing to the level where it is capped by the limits that are imposed on it by available food, or space, or some other limited factor.

A very important consideration then, is the fundamental ability of this resource to replace itself over a long period of time. Recuitment is related to the size of the spawning stock. The spawning stock generates eggs; those eggs pass through a survivorship gauntlet; and you end up with a recruiting year class. In the past, scientists have developed static spawning recruit relationships. They are based on fundamental concepts in biology, such as density dependent mechanisms or compensatory mortality. They are conceptually reasonable, based upon our knowledge of biological processes, but when fitted to the data, they seldom reflect the real world. There are some populations that happen to fit such stock and recuitment relationships. Most of the populations that we are dealing with in the Northeast simply don't. Nevertheless, if you're willing to back away from the formalism of these stock and recruitment relatonships, and you are willing to accept that there is a fundamental relationship between the size of a spawning stock and the subsequent recruitment it generates, then you can derive some practical relationships concerning long-term stock replacement. This, again, has been as important aspect of the Council's approach to fishery management.

Illustrated in Figure 3 is total spawning potential, which you can think of as the spawning stock biomass produced by a cohort over its life in the fishery. The way you would calculate spawning stock biomass is by simply integrating under the curve. If you start to fish off that resource at age 2, you can see that the spawning biomass is lower at each age, and if you are fishing it off at age 3, you can see that it's higher.

Figure 4 illustrates recruitment data that we've been able to measure at age 2 against spawning biomass that pro-

Figure 1 **POPULATION DECLINE**

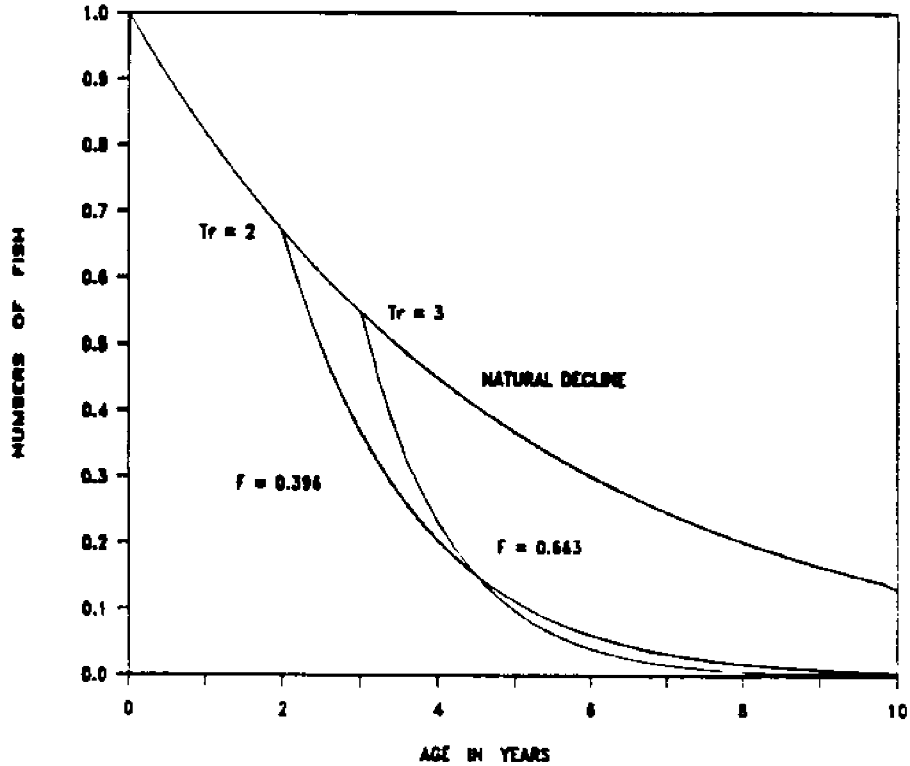


Figure 2 **YIELD PER RECRUIT**

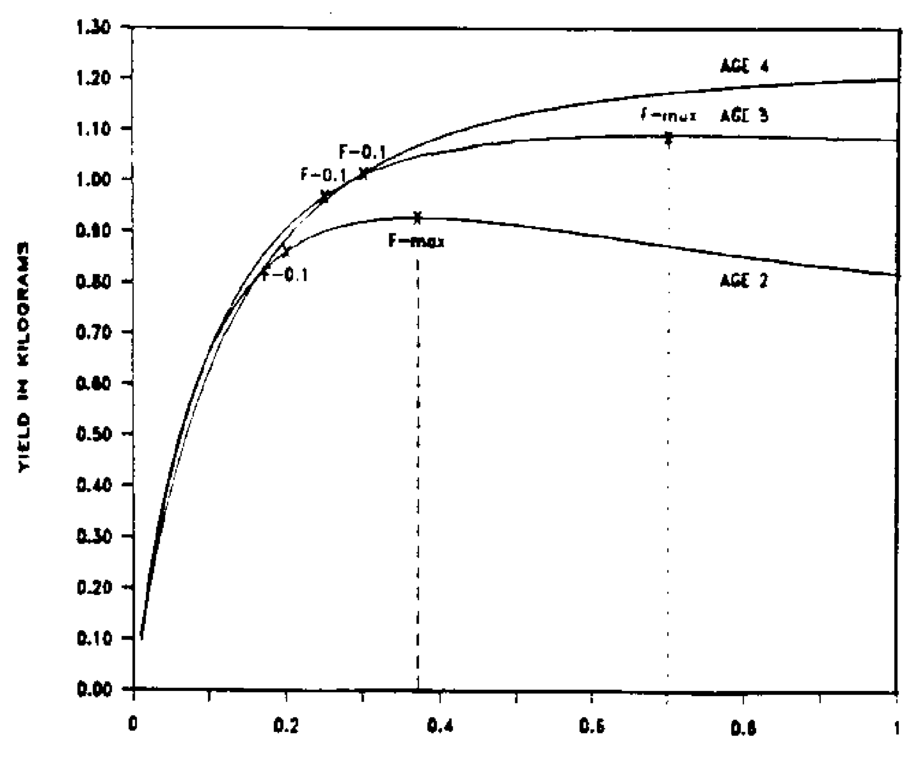


Figure 3 **STOCK REPLACEMENT**

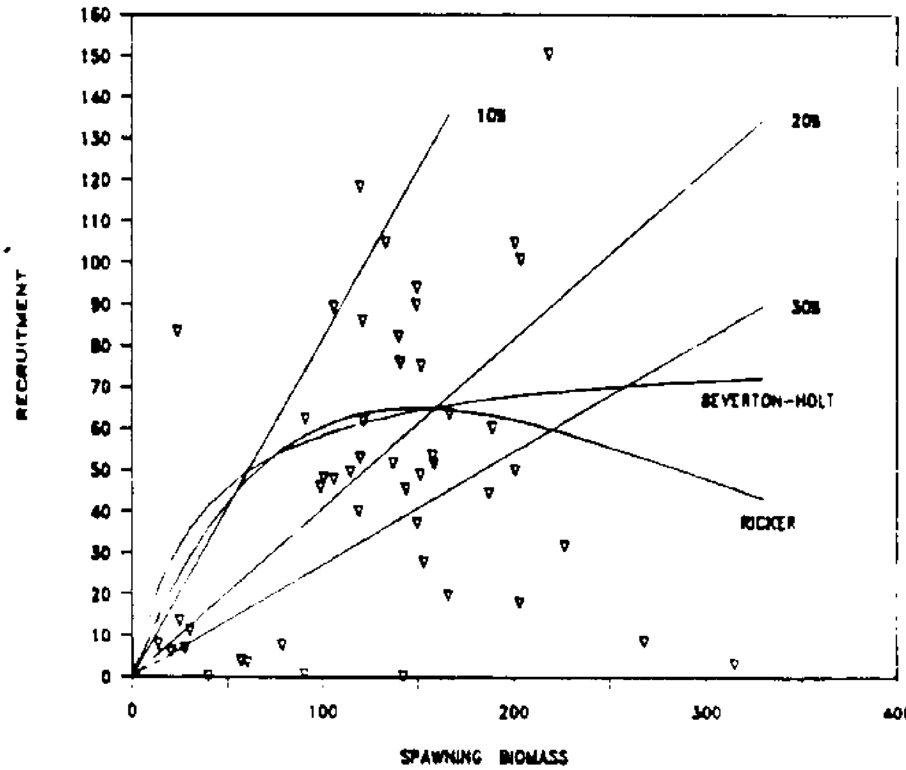
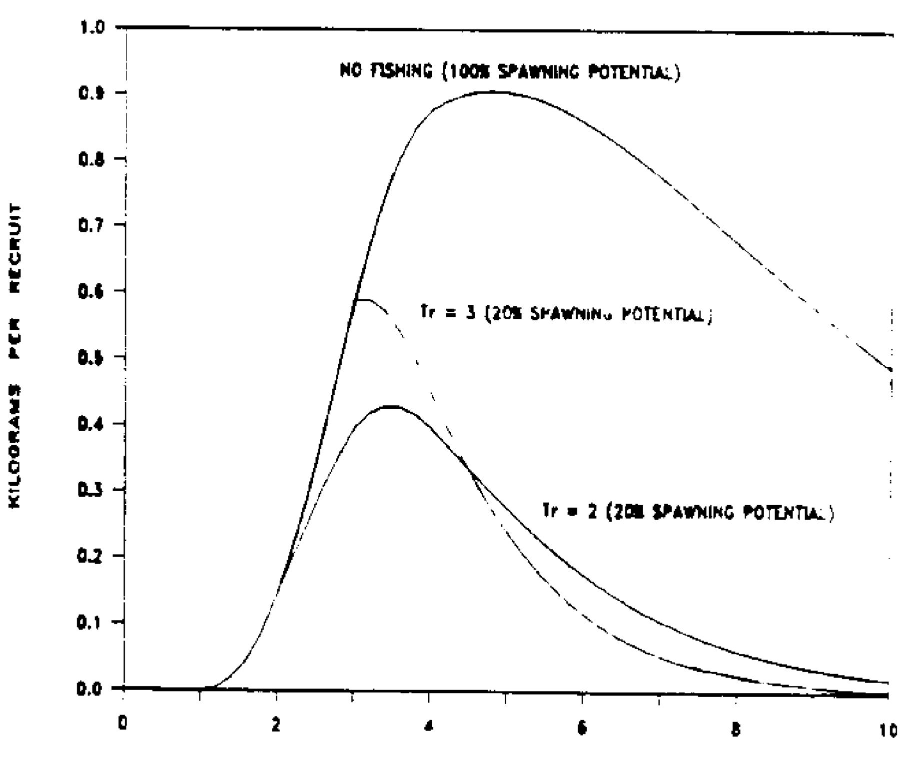


Figure 4 **SPAWNING POTENTIAL**



duced it. Two stock/recuitment models have been estimated using these data. While the shapes of the curves are typical, we are not entirely sure that they provide much biological information to quick management. What we think is important from a management perspective is that, if you want to sustain a certain size spawning biomass, the stock has to generate the average level of recruitment corresponding to those that have been observed. I have overlaid the data with lines of constant spawning potential, each corresponding to a specific level of exploitation. The line that bisects the observed recruitment data is called the "average replacement" line and implies an optimal level of long-term exploitation.

It turns out that the 20% maximum spawning potential line does a very nice job of bisecting the recruitment data. In other words, there are as many points above the line as there are below the line. Your classes that are above the line will push the stock up; year classes that are below that line will decrease stock size. The net effect is a population within a fairly stable range of biomass.

This is the approach that the Council has taken in its management efforts for groundfish and sea scallops. We have found that the 20% line is a fairly reliable first estimate of the target level of spawning potential that you want to generate within a population. In the case of haddock, we are currently below the stable range. Recent observations of recuitment have been poor relative, to the historical distribution of recruitment observations. As long as haddock biomass is in this low range, the stock requires a different kind of strategy. We have selected the 30% line as the basis for current management measures. We have also incorporated into our plan other measures that will have the effect of directly protecting a year class of haddock, should that in fact be necessary. Figure 5 illustrates the effects of superimposing various percent maximum spawning potential (%MSP) isopleths on historic observations of haddock stock and recruitment.

Figure 6 illustrates how age-at-entry and fishing mortality controls combine to achieve various levels of %MSP. As it stands right now, fishing mortality is relatively high: it is probably between .6 and .7. If that's what the fishery is capable of generating, then the strategy to maintain 20% MSP would be to ensure an age at first capture of about 3 years of age. One of the most attractive features of age at first capture as control variable is that, at relatively high fishing mortality rates, the 20% line becomes almost vertical. As it does, the stock is relatively buffered to the effect of fluctuations in fishing mortality. Control on age at first capture is particularly useful is you neither have, nor expect to have, control over fishing mortality on the stock.

If we were dealing with a single species fishery, one which we knew contained only dedicated fishermen, we could probably consider controlling fishing mortality much more directly. But when you are dealing with a multispecies fishery, as is typical off the east coast of the United States, you have the same fleet of vessels targeting a range of species, either collectively or sequentially. It is extraordinarily difficult to determine exactly what constitutes a unit of fishing mortality when you have to refer to fleet units, days fished, or number of boats. It is very difficult to control fishing mortality over a wide range of species when you really don't understand how a particular fleet concentrates its fishing effort. It's also difficult to design a fishery management plan that allows you to simultaneously determine appropriate ages at entry for a whole range of species. A major consideration in the design of the groundfish management program has been to provide as many opportunities as possible for fishermen to continue to fish on alternative species such as squid, butterfish, mackerel, whiting, dogfish, red hake, and other undervalued species. These species are relatively abundant and are good alternatives to the traditional cod, haddock, and yellowtail flounder.

Thus, the approach the Council has taken has been to identify areas that are descriptive of biological assemblages and to require the use of large mesh in those areas that will select for the desired age groups. While nothing is exact, most of the Georges Bank area, with the exception of the shelf area to the south, is an area in which cod, haddock and the flounder are likely to be found. Of course, they are going to be found inshore as well, but we've decided that if you want to try to control age at entry on cod, haddock and the flounders, you might as well do it in the deeper water areas and on the shoal areas of Georges Bank, because this is the area where there is probably less opportunity to conduct a fishery for other species.

A complicating problem is that you have to provide opportunities for small mesh fisheries that occur in times and places where groundfish species are abundant. Shrimp and whiting have to be conducted in concert with a large mesh fishery. We have provided for them in a way that we hope will have minimal impact on groundfish, but we've also set up standards that we're not entirely sure can be met. For example, we have provided for an exempted fisheries program using small mesh gear if the by-catch of groundfish species can be limited over a 3- day period to 10%. If you are in the fishery focusing on whiting, then no more than 10% of your total catch over 30 days can be regulated groundfish species.

In the shrimp fishery, we allow for the conduct of a shrimp fishery, but by-catch has to be limited to 10%. It's the kind of standard that can probably be achieved if you are prepared to use gear that selects for shrimp. That is the direction in which to push the industry to conduct legitimate small mesh fisheries in the cleanest possible way.

In addition to that, we have the possibility of closing areas to control mortality and protect juveniles. This is different from the closed areas that we have for spawning. The spawning area closures, which have traditionally been closed areas in which the fish are allowed to congregate and spawn, have benefits which are very difficult to calculate.

Thus, the council has adopted two strategies that are age-at-entry oriented and one strategy that is fishing mortality oriented. In southern New England there exists a fishery that is predominantly small mesh, whereas north of the Cape and on Georges Bank the fishery is more predominantly large

Figure 5 **STOCK REPLACEMENT**

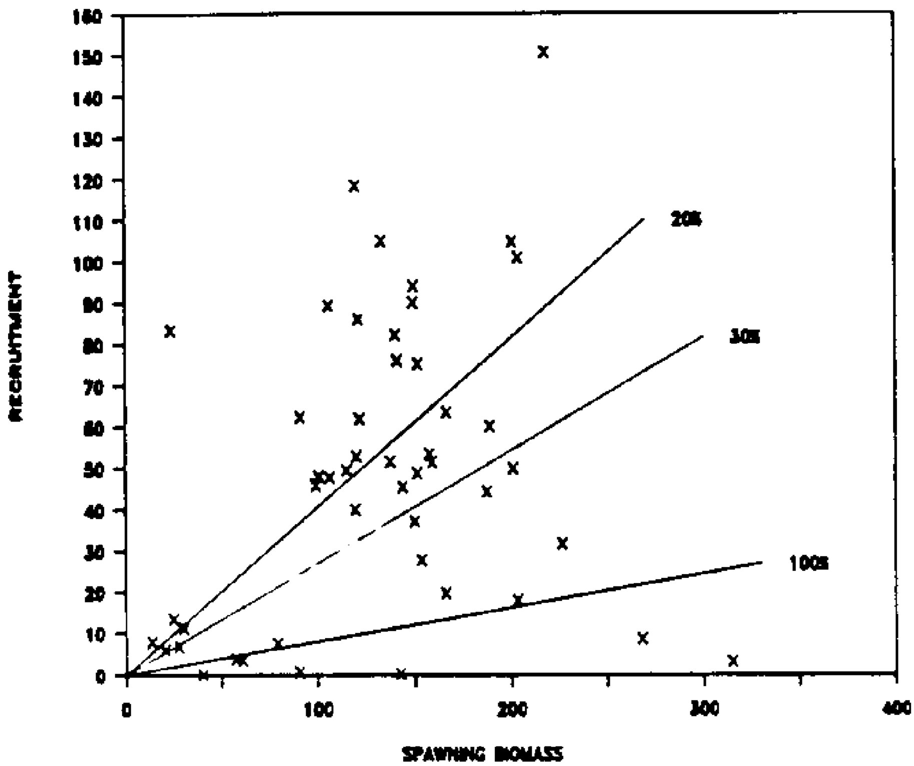
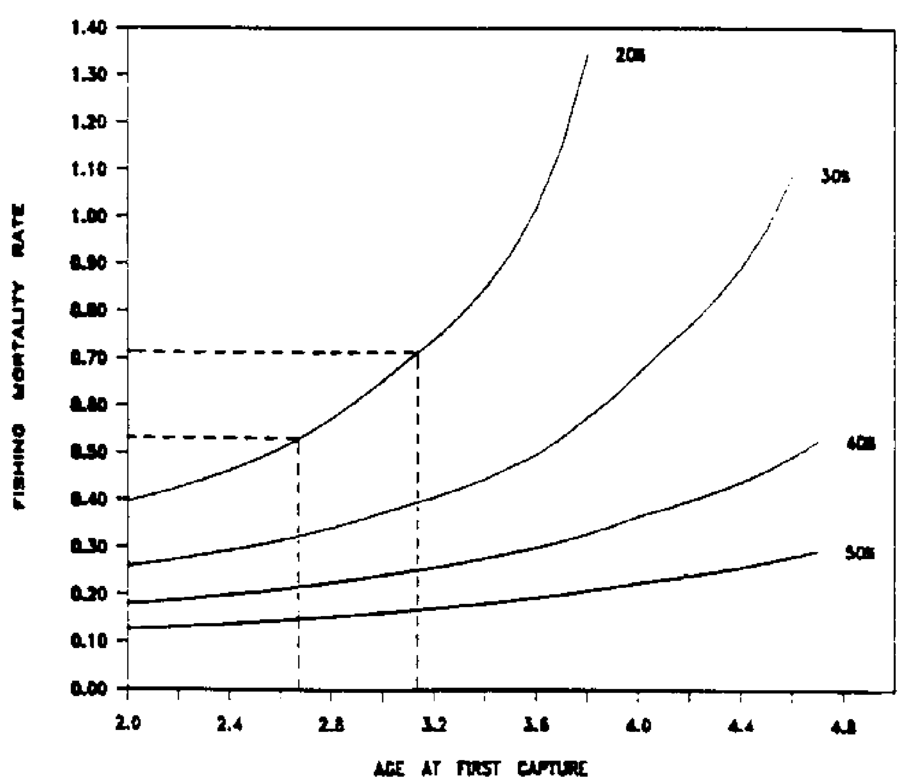


Figure 6 **SPAWNING POTENTIAL ISOPLETHS**



mesh. As a consequence, one measure may take precedence in the larger mesh species areas, whereas another measure may take precedence in southern New England, because it's the least obtrusive to the traditional conduct of the fisheries for scup, hake, or butterfish.

In the case of scallops, we again employ an age-at-entry strategy through minimum shell height. There is indeed a minimum shell height measure and an average meat count in place. Both regulations are designed to control age of entry. They are generally regarded as being effective in terms of generating sufficient yield per recruit and long term reproductive potential to ensure the long term persistence of the population.

I've also indicated two other age-at-entry approaches that we are working on right now through selective gear. In scallops, gear that is capable of discriminating between an under-four-year-old scallop and an older scallop is critically needed. We're also looking at the possibility of closed areas. It is again an age-of-entry strategy because closed areas are being used to take the pressure off juvenile scallops as they recruit to the fishery. In other words, areas would open when the scallops were at a size that would be acceptable from an age-at-entry point of view. So it's pretty clear that age-at-entry is a commitment in both of these management plans. The lobster minimum size measure is again an age-at-entry strategy.

Earlier, Cliff said he hoped I would talk about what it is the Council wants and what we really would settle for, to help guide us in deciding what the priorities are, how much money to spend, and how quickly to do it, as well as the depth to go into and how much statistical reliability we need. I don't have the answers to all those questions but I do have some suggestions.

First, let's start with the priorities. We clearly need finfish gear that will select more reliably for round or flatfish under all fishing conditions. I say all fishing conditions because very often gear work is done under optimal conditions using short tows in relatively calm seas and at relatively good times of the year. What you don't have in looking at the selectivity of gear is a real sense of how that gear performs under conditions of long tows, of high abundance, or in trashy conditions. All these conditions have had a lot to do with the effective, practical selectivity of the gear. When you talk about gear modifications such as square mesh, you talk about whether or not it is a suitable substitute for diamond mesh. I think it's fair to admit that while we have a lot more data right now on diamond mesh selectivity, it still suffers from being unrealistic within a whole range of fishery conditions. It's very likely that the selectivity won't necessarily be the same in the actual operation of the fishery.

What I define as being reliable is clear selection, i.e., a more vertical selection ojive, and selection that is not diminished by loading. These are factors that have already been tested. These are the factors that MIT has already looked at in the test tank studies using various models of trawl gear. MIT has looked at how these gear configurations operate, how the apparent selection changes, and how the conformation of the gear changes as you begin to load up the net.

I think gear ought to be defined such that selection is not a function of how it is loaded. It should continue to maintain the same selectivity characteristics under all conditions. I don't think that's the case with diamond mesh gear due to the "necking down" of the codend and the blocking of the meshes.

Another suggestion is to develop gear that will allow legitimate small mesh fisheries to coexist with large mesh fisheries by providing for directed catch of the small mesh species, with minimum by-catch of the species under regulation. We want to be able to provide as many opportunities to conduct small mesh fisheries, particularly for ones that have market potential, but we don't want to do it at the cost of undermining our ability to effectively deal with the high-valued resources of cod, haddock, and the flounders.

In regard to scallops, the first priority is gear that will reliably select between 3 inch and 4 inch scallops, both by dredges and by nets. The second priority for scallops is gear that will minimize mortality on scallops that are not selected: the ones that are left behind. We need ways to reduce trauma that leads to mortality. The third priority is gear that minimizes habitat damage. One of the advantages of the "cage dredge" is that not only does it have better selection properties, it also has much less physical impact with the ground below it.

The community of gear researchers should not go off and look at designs all by themselves. The design work should come in cooperation with the ideas of the industry. The reason for this is twofold. First of all, money is better spent on things that people believe in; it's much more cost effective to have fishermen participate in the process of looking at more selective fishing gear. The process so far has been distinguished by this very factor. There has been a tremendous amount of input by the fishing community to the gear design area. But, I don't see a lot of money being spent. Perhaps it should be ideas that come from the fishermen themselves who have an essential understanding of how gear operates, working in cooperation with the technical capabilities of gear researchers, whom we prioritize for research funding.

I am not suggesting that gear research ought to be solidly at the inititation of the fishing industry. I am saying that there has to be a commitment on the part of funding agencies, whether they be federal or state, that have an interest in fishery management to put up funds to support this and to also provide a consistent supply of personnel and physical resources to assist an on-going effort to perfect gear. The level at which we do this is the level defined by just how good you want the results to be and how much statistical reliability you want to have. We can focus our funds through a group of people who sit down and look at a project and decide almost from an engineering point of view what is capable of being produced, and what it's going to cost.

There are a couple of ways you can approach gear modifications from a management point of view. You can require that every fisherman uses a specific gear, but you can only do so if you're confident that it does exactly what you want it to do. You understand the cost of implementing that gear, you have decided that the costs are worth it, and you're ready to go with it.

Another approach to gear modification occurs when you are fairly sure that you've got the right piece of gear, but want to introduce that gear gradually and gain industry acceptance. Management has the unique ability to provide incentives for using different kinds of gear. For example, we can say under the current management program that a fisherman either has to have 5-1/2 inch mesh and follow certain rules or, if he's prepared to participate in gear research, he can be exempted from some of those rules and regulations. This approach can provide a positive incentive in terms of what people are able to do or the amount of money they are able to actually generate from their fishing operations.

In the case of shrimp, you could require that the most desirable shrimp season be in the coldest weather months, such as January and February, but allow shrimping outside of those two months if a separator trawl is used. What you're doing is providing a positive incentive for people to make that investment.

Comment, Jake Dykstra: We're both very excited about the possibilities that have been raised in this conference. I think it's important that we are on the right track. The square mesh appears to me to be a very useful tool in the southern New England fishery and it looks as if the problems are more technical: trying to get the thing in the right place at the right time and keeping knots from slipping. All this is more technical, but I think we are on the way with that. I think the separator trawl has great possibilities. We spent a lot of time this summer on our hands and knees picking through fish to get squid out of it. The possibility of putting two bags and the right kind of mesh on this kind of net, towing it along, and hauling back one bag of squid and one bag of good fish with the trash out somewhere else is exciting. I think this bears out what Guy said. Rather than use management measures that are very difficult to enforce and trying to force fishermen to do something that has a disincentive, if you can get something that has an incentive, you're on the way. It seems to me that this is what we are talking about here and what is happening. These things are far from perfected but I find them a very interesting way to go. I think that they are good. On the other side, I think it's important to note that the scallop problem that looked so horrendous yesterday is not a biological problem; it's not an ecological problem; it's not an economic problem; it is a social problem. People try to present these things as more biologic and more economic, but they are social problems and if society doesn't want to enforce that regulation, then there is not much you can do about it. It can only be done if society wants to do it.

The inexpensive vehicle being developed by MIT is something that is very exciting. I think, again, that it's astounding that we're getting down into the price range where perhaps we can really do some things with the right kind of gear. We've talked with Cliff Goudey and Paul Shuman about problems like knowing what the difference is when you go in fair tide and when you go in head tide. We don't really know what happens down there under these conditions. We can't find it out in the tank, but with a vehicle like this we should be able to learn these things as the vehicle is improved.

A word about the paper that Mr. Cahill passed out yesterday. I still feel I have some small amount of influence on management and have had considerable experience with it. As a manager, I would be very turned off by such a paper. It purports to be a technical paper, and then starts with an introduction that is a lot of unfounded allegations and assumptions that the authors themselves won't back up. It's kind of a soap box affair and that turns me off very much. It has nothing to do with a technical paper. It's just peddling medicine and I don't go for it. So, I would say those of you in the room who are technical people and want to sell your product, don't approach it this way because it turns me off. We're not quite that gullible.

What we need to remember is that the purpose of management, in the law and in the U.S., is to produce something of value to both the fishermen and to society, while also striking a balance between these two. It is not to keep fish at any level of abundance. It's not the greatest thing in the world to have fish swimming all around the ocean if they don't produce any value for somebody. The assumption that to have more fish in the ocean automatically means more value to society is a wrong assumption. We ought to keep that in mind if you want to know how to relate to management.

The last thing I'd like to say is that it's an age-old problem that I've dealt with for 30 years. There are not many fishermen off the boat here and I think that a lot of them would be very supportive of these ideas if we can bridge that gap. We've always had trouble bridging between the technicians, the managers, the bureaucrats, and the guy on the vessel. I think the money is there; I think you can even raise the money from fishermen for a lot of these things; but it's a really difficult job to know how to go about getting from the shore people to the sea people.

Improved Enforcement Through Gear

Ron Smolowitz
NMFS, Gloucester

Most of my career has been spent either driving ship or doing gear work, but around January 1985 I was sent up to the regional office for an assignment. That has been a totally unique experience. At one time, I was quite heavily involved with the concept of mesh size as a way to control the ground fishery and I became a strong advocate of it. I initially saw that there would be an enforcement problem that would have to be dealt with ,but I didn't know anything about enforcement. Then I was sidetracked to other things, so I lost track of what was happening.

The fisheries managers and scientists said it wouldn't work. That opinion was based on the experiences in Europe over the past century. They still say it's unenforceable. When I went to the regional office, I decided to look into the enforcement situation and I want to mention what I've experienced.

Enforcement people are different from scientists and seagoing people. Their problem is gaining compliance so that management goals can be attained. It's a simple problem. Most enforcement professionals, of course, simply want to carry out the law, rather than evaluate the law.

The first thing for which enforcement and gear research compete is the limited government dollars in the budget process. We put in a budget initiative for 1989 of $4 million nationally to do gear research in support of the Councils for solving management problems. We fought that budget through NMFS. We managed to get it through NMFS headquarters, but it was killed at the NOAA level. However, they added $1 million for enforcement, which Congress has since cut. We were in direct competition for funding; it was either gear research or enforcement, and enforcement won. That $1 million nationally for enforcement would have bought a few more agents.

An analogy to this might be a forest fire with 100 people on the line. We're losing ground, and someone sends in 10 more firefighters. Do you put them on the line to slow down the fire, or do you take those resources and put them somewhere else, to dig a fire break, or develop some way to ultimately stop the fire? What happens is that the government fights fires; they decided to forget gear research. Enforcement is where we're putting the money and we have to keep that in mind. Gear research is a lower priority.

The second point is that many fisheries managers and scientists are also competitors in the budget process and they say there is no need for gear research. The common line is, "It's already been done." For example, a lot of people have done scallop gear selectivity studies. Therefore, they would say there is no need to do it again. An analogy would be a couple of cavemen sitting around a fire and saying we know everything there is to know about spears; there is no reason to invent the bow. There is no reason to spend any money on gear research. We know everything there is to know. That is a common attitude in government.

My third point is that the simplest and most effective form of management, from an enforcement perspective, is gear regulations. Landing only legal or desired catch on board could only be accomplished by better gear design. If everything that is brought on board is to be landed and marketed based on the management objective, we will need improved gear selectivity and species selectivity.

One thing we're not addressing, though, is the overall amount of the harvest in the fishery, called effort. That's a separate problem; we're not talking about effort controls when we're talking about gear research. That has to be kept in mind since there are indirect aspects of effort control in gear due to the vulnerability and availability of a species. There are some indirect effort controls if you have a set of gear regulations.

My fourth point is that we're not necessarily advocating inefficiency. However, gear control or gear measures can make an individual operator less efficient, and it's up to the managers to decide which efficiency they are talking about, the individual operator's efficiency or that of the overall system. The system approach takes into account social needs, consumers, management and enforcement costs, and the resource itself. There has to be some definition as to what efficiency we are targeting. An example of this occurs when we talk about species selective gear. We could, out of concern for small mesh fisheries, replace small mesh fisheries. For example, squid jigging could replace squid trawling in a directed fishery. Now, trawling might be very economically efficient for an individual operator, especially if you take into account the mixed species aspects of a squid fishery. But, from an overall systems standpoint, there might be advantages to jigging, such as no by-catch and greatly reduced gear conflicts, as the means to catch squid. In addition, you can reduce the enforcement burden significantly when you have a very particular piece of gear. You don't have to worry about mesh size enforcement; you can direct your effort onto another fishery.

So what we have now is the question, "Do you have the individual operator who could be more efficient as a trawlerman?" or "Do you think of switching the fishery into a different set of gear for more overall efficiency?" Many years ago, when foreigners were coming over, we advocated that they should only be allowed to jig. If they wanted a TALAFF they would have to jig for it and that technology could then be transferred to the American fleet. The Japanese don't allow trawling for squid. They require jigging even in their own waters.

Another aspect is that gear research is very expensive and it takes technically trained people to do the work. The government spends a lot of money holding conferences; people can come, and give their two cents on limited entry. Everybody has an opinion on that. By contrast, very few people can come and give a technical presentation on gear design. Talk is cheap, and a lot of times the management techniques tend to lean toward the techniques that everybody can talk about and not spend the money to conduct the necessary research. The scallop industry said, "Hey, we don't like the management plan. We want it managed by gear and we're willing to put up the boats and the money." The managers said, "Fine, you guys fund the gear research; prove to us that it can be done." They never asked the fishermen to do that for limited entry because everybody could debate about limited entry and they don't need anybody to pay for it. So, when we go in and say we need a million dollars a year to do scallop gear work for ten years and guarantee we can probably design a better piece of scallop gear, we get nothing. However, the payback on that expenditure might be less than a year if you achieve an order of magnitude increase in yield. That could be possible with a proper piece of gear in a scallop fishery.

Gear research is expensive, and that is one of the reasons we can't seem to get it done. We haven't been able to justify the expense. Major enforcement problems can be solved by gear design if, in fact, you could design the proper gear taking into account what efficiency you're talking about and your management goals, and mandate its use. One example of this process was the porpoise-tuna problem in the Southwest. They tried all sorts of approaches, but until they invented the Madina panel and the operational procedures of backing down, both gear-related solutions, they couldn't solve the problem. They eventually had to spend several million dollars to do the gear work and solve the problem. In the Southeast there was a problem with turtles. Money had to be allocated, $1 million if not more, before they came up with the Turtle Excluder Device.

When is the gear work done? It's not done until it's applied and that may never happen, even though it's successful. One example I can think of is the ghost fishing work Al Blott and I did in 1974. It isn't until 1986 that Maine is first considering ghost-trap escape panels. So even though we might have completed the gear work 12 years ago, it's really not completed until it has been applied and seen operational experience. Of course, there are examples of successful gear research that was funded and helped solve major management issues.

The other thing we have to remind people about is that gear is not the sole alternative to these other management approaches, no matter what type of management system is used. Whether you go to the extremes of limited entry or quotas or closed areas, you still want size selective gear or species-selective gear in certain situations. So going to another management regime doesn't necessarily mean that you eliminate the need to do gear research. The question, of course, is the definition of optimum gear.

Another point from the enforcement perspective is that the Coast Guard cannot enforce fisheries regulations. We have to accept that fact. The president, the Congress, everybody has told the Coast Guard that his main emphasis is going to be drugs. Budgetwise, the Coast Guard has come back to us, with a total of 550 medium-endurance cutter days for the entire East Coast, and the most we could get was 220 of those days. An average of 1-1/2 boardings per day is the long-term average, meaning we could get 300 boardings from the Coast Guard for all of the East Coast fisheries. We can't expect to manage all fisheries with that number of boardings at sea. It's not going to work. You're not going to get compliance and that has been the major reason for the lack of success in using mesh sizes.

I've looked at the data based on the boardings, and I would say that during the first six months of this year, the compliance rate on mesh size offshore is down around 30%. Many vessels now have 5-3/4 mesh on board where before they might have had 5-1/8, but they are all putting in liners. We are seeing a tremendous number of boardings that find liners on board. From a gear standpoint you have to have regulations that encourage compliance. You need people believing in the regulations. I would say that on half the boardings where we find small mesh on board, we cannot violate the vessel just because of the way the regulations are written.

Yesterday we heard a lot about the catching of small scallops and the lack of enforcement. To get into that particular issue, we sent a lot of enforcement agents down and we made many boardings of the netters as they landed. They were landing legal size scallops. The problem is in determining what is the legal size shell versus shucked meat. The shuckers had to land a 30 meat average which might be a 4 inch shell. But a shucker can mix. He could catch and shuck a 2 inch scallop but mix them with meats from 5 inch and 4-1/2 inch scallops to get his 30 meat average.

The shell stockers said, "That isn't fair. If you make us shuck all 4 inch scallops, we'll be landing a 30 meat minimum. We need a shell size we could shuck that would average out roughly to a 30 meat." The typical shell size was 3-1/2 because the overwhelming majority of the scallop population fell within that range. They turned out to be a 50 meat count and this, of course, upset the shuckers.

So it's not a clear cut thing of not enforcing the law or landing illegal scallops. It's more of a social problem. Where do you set the shell size of a shell stocker versus the shuck meats of both netters and dredger boats that are landing shucked meats? This is not a gear design problem, but it certainly is an enforcement problem.

The last point is that not only do we need to evaluate our ability to achieve size selection and species selection, but also must make the rules enforceable. What are the complimentary set of regulations to make them enforceable. We could have mesh size or ring size, or bar spacing in the case of clam dredges or headrope height, or even gear type limitations, but you need additional complimentary regulations to gain compliance. You must make sure that individuals are fishing the proper gear, but also that the general fishing community has the sense that everyone is playing by the same set of rules. Sometimes you might have to go to great lengths to do that in a set of regulations. They might have to contain things in addition to size limits. One possibility is an industry-derived quota that reflects the maximum catch that one could expect a highliner to make using the

The worse thing to do is to put a gear regulation in force and have the scallop industry against it. However, what happens if you could bag a guy dockside if he has illegal gear and a fellow comes sailing in with 20,000 pounds of 80 count scallop and legal gear onboard, while the fleet is landing an average of 6,000 pounds of meats at 30 count. This is one of the reasons that you have to have a size requirement in conjunction with a selective gear regulation. Another potential problem is what happens, for instance, when you are trying to regulate a particular fishery and decide on a particular gear and its selectivity and the fleet is fishing and landing 20,000 pounds per trip. What if somebody comes in with 80,000 pounds? Don't we need some sort of cap, not only for the guy who might be fishing illegal gear, but for the guy who might make the quantum jump. This is clearly a social issue.

If you restrict and legislate the gear so that everybody is required to fish a particular mesh size or a particular width of dredge with a particular selectivity, what happens if somebody makes the technology quantum jump. Let's say he tries a hydraulic scallop dredge and catches four times as much. That could start an arms race of sorts. From a gear standpoint, do we want to put caps on the technology that we have now? That is another aspect we have to keep in mind when we design new pieces of gear.

A final type of gear restrictions that we don't much talk about is when we have good bottom areas and hard bottom areas. One form of gear regulation is a type of gear that restricts the gear so that it cannot fish on hard bottom. In other words, you can have restrictive measures that limit or prevent the use of chafing gear on scallop drags or even limit weight or gear restrictions that limit the size of roller gear, for example. There are gear measures that can be used that would effectively close areas, and you would not have to enforce it by having the presence of enforcement officials in the aircraft or vessels. You could enforce it by just limiting the gear dockside so that people cannot fish on certain types of bottoms. This is another aspect of gear design that people need to consider.

We have to let the managers and the industry know, for example, that, given some research money, we might be able to exploit the difference in squid behavior in the squid/butterfish mixed fishery. We could make a species selective squid trawl. We have to say that's possible, we certainly don't have the money to do it. We need to develop an industry lobby that will say, "Hey, instead of spending money on enforcement, let's spend the money on gear research to develop this piece of gear." The industry has to explain that it would rather see gear work done and it would rather see government fund it in lieu of something else. Nowadays you have to tell the government how you want to spend your money. Then, with the support of the industry and the management authorities, you conduct some work. Then it would be up to the management authority to decide. I think that's the way it worked in doing the mesh experiments. It upsets me that industry is being asked to pay out of pocket for scallop research that I think should be funded with federal dollars.

We did a good job, I think, in getting MIT money for the submersible vehicle. We had a hell of a lobbying effort to get money to be spent at all on conservation engineering out of the S-K funds. As a matter of fact it's been a six year battle. Most of our conservation engineering projects have been killed going through the S-K funding process because people in various levels of the system didn't feel it was worth funding. We had to educate them. Then it was the NMFS people in the regional office that didn't think it was worth funding. We had to educate them. The following year it was the Washington office NMFS people. Eventually, we had enough of a ground swell where everybody wants to fund conservation engineering projects, at least up through the NMFS level. It can still get killed at the NOAA level. That is the next level that we have to educate.

One other aspect of the enforcement problem is the size of a penalty. To give you an example of how the system works, let's say a scalloper landed 18,000 pounds of scallops. The agents came aboard and sampled 20 samples in the usual manner, and they found that 10 of the 20 samples were under the legal size of 35 count. The other half were legal. Based on this sampling, they said that half of that catch on board was technically undersized. When they added up the fine several months later, due to the slowness of the system, they gave the guy a $2,500 fine for illegal landing of scallops, and then assessed the value of the illegal catch, which came to something like $18,000. Yet, if you averaged the 20 samples, it came out to a 36.1 meat count. So the same industry that normally yells and cries for enforcement, went and yelled and cried to its political lobby and said, "How is a fisherman going to make a living? A guy gets fined $17,000 for landing a 36.1 meat count." The orders came down to mitigate, giving him a $3,000 fine. So here is the guy who landed an illegal harvest. He gained somewhere on the order of $30,000 and had to pay a $3,000 fine.

That is the enforcement situation today. The industry has to solve it. The industry has to decide what the penalties should be for violating regulations.

Limitations of Practicality: A Net Maker's Viewpoint

Paul Shuman
Shuman Trawl, Inc.

My job is commercial net making, and I think one thing that has been noticeably lacking here is the perspective of my end of the industry. I think it's important, since you're suggesting regulating my sole product, in addition to suggesting how I ought to make that product. So I would like to shed some light on how I perceive some of these issues. I think a lot of my opinions are representative of other people in my business.

First of all, I see my main objective as building a product, in my case a trawl, that will catch whatever species or whatever range of species my customer happens to be targeting. That is my number one objective. If I don't achieve that, I probably won't sell another net. There are some secondary things that are always on my mind related to that. The product that I make has to be a viable product. It has to be able to operate under the conditions imposed on it by the fishery. It also has to be maintainable, so we usually take one or two courses to ensure that we stay on top of this concern. Either the product is intended to be returned to the manufacturer for maintenance or it's designed in such a way that the user can maintain it himself. Different fisheries dictate different approaches. Also very important to me is that the product is economical to manufacture. I'm in business to make money, to make a profit by manufacturing gear. I have no choice but to be concerned with what materials are available to me, the cost of those materials, and the kind of skills I'm able to impart to my employees in order to manufacture these products.

Another factor involved in my job is the evaluation of everything I make. This is true of any net maker. As soon as you make a product you're interested in how it's going to work. You poll the customer as often as is practical. In my case, I spent a lot of time doing repair work on gear and I pay a lot of attention when the product is returned to me. So you are constantly considering changes that need to be made, and it's actually through this process that most of the evolution of our product takes place.

One thing that is often not on my mind is whether or not the product I'm making is selective. That's an important point. What someone sees as a selective piece of fishing gear is viewed by somebody else as a net that doesn't catch. That's not a trivial distinction. There have been no real restrictions imposed on my operation that have been a handicap to me since I've been in the business. We use whatever mesh size is allowable in a certain area, 5-1/2 inch for nets in Maine, for instance. The only time we go a little further towards making things more selective is when we handle a specific problem. For example, if somebody is fishing in particularly dirty conditions with a lot of starfish, we might try a manner of footrope rigging to eliminate that problem. Some of the techniques are probably related to some of the things suggested here, but I think the intents are, in many cases, different.

Another example would be our manufacturing a product that will have gilling problem in some areas of the net with certain species. This situation may dictate a mesh size change or a taper change in that area. Tail piece and codend mesh sizes frequently change as markets change. Again, this is more to satisfy the requirements of the user; it is not to dictate what he can or cannot catch with the gear. Flappers are another thing that we may employ in certain instances that might have an effect on selectivity. These are some of the things that we do that may be construed as being related to the selectivity of the product.

There have been several methods talked about here and I would like to make a few additional comments on them from my perspective. First, let's look at codend mesh size. That is a fairly easy requirement for me to fulfill. I can understand the requirement, I can buy codend webbing that is legal, and I can use it. Somebody made a comment about mesh shrinkage. That certainly is the situation, I don't know if it's a problem. Things commonly done to counteract mesh shrinkage relate to choosing proper materials. Primarily we use polyester or polyethylene codends instead of nylon, which has a greater shrinkage problem. The issues still exist.

What if the fellow starts out with a legal bag and in a month's time it's no longer legal because of the way it's being used or because the material itself simply shrank? This is a serious question; what would you do about it? One solution might be to purposely use oversized mesh bags as lifting bags and then use liners. I haven't heard anything very conclusive here on how that affects selectivity, and it's an important issue. Does a legal size liner within a over-legal size bag select the same way as a legal size bag? I'd suggest that it probably doesn't. Does the number of meshes around a liner affect selectivity even if we maintain the same mesh size? I suspect that it does, but I haven't seen that quantified in any way. These are some of the issues related to strict mesh size considerations that I think would be difficult to quantify.

Something else that has received a lot of attention here so far has been square versus diamond mesh. Many of the problems of knot slipping and similar problems have been well handled here. I've had similar experiences myself when I tried out my own square mesh experiment with a customer in a butterfish fishery. It was in the form of a square mesh extension piece on a diamond mesh codend. It didn't survive the trip. It seemed like a nice way of throwing away netting.

Based on what Fred Manterra said of the Point Judith experiments going on now, that problem is probably somewhat manageable with gore ropes. The use of the knotless netting has also proven to have some merit. At any rate, all of these things involve a degree of difficulty in manufacturing that, from my point of view, I'd just as soon stay away from. My goal is not to make things as difficult as or complicated as possible to manufacture, but to do just the opposite. That has to be my approach.

I don't know how the majority of you feel, but the selectivity data I've seen so far relating to square versus diamond wouldn't convince me of anything, other than the probability that it is going to be impossible to get that information in any reliable way. It also seems that you'll have to get that information for every fishery where you're considering using square mesh. The Scottish videotapes of fish swimming out of their tail pieces don't have a lot of significance for me and I don't know how it relates to what's going on here. A big area that seems to have been overlooked is the rate of catch in many square mesh experiments. The data I've heard about has been in fairly low volume fisheries and low catch rates compared to fishing for mackerel, butterfish or any of the pelagic species where large tows are more common. I think that would have to be evaluated before I'd be willing to put up with any requirements for square mesh and those sorts of products.

One other thing that Cliff mentioned yesterday was something he and I did a couple of years ago comparing some diamond mesh and square mesh configurations on a regular bottom net in the flume tank. They were revealing to me. It suggests to me that the simple idea of square mesh is actually not as simple as it appears. There is quite a bit of variation possible in the performance of both styles depending on how things are rigged. I'm still not convinced that the selectivity possible with square mesh couldn't be duplicated with diamond mesh if it is rigged properly, just as square mesh has to be rigged properly in order to keep it from self-destructing. Those are just some thoughts that occur to me on square versus diamond mesh. Although there frequently is interest in square mesh, I don't feel compelled to try and sell it to my customers.

The separator panels, the shrimp separator trawl, and the related devices are pretty neat and it seems fairly conclusive that they work in a lot of cases. However, I see a vast difference among some of the designs proposed, from my standpoint, as far as installing them, maintaining them, and ensuring that they work.

Typical to a lot of things that come out of Aberdeen, the horizontal panels through an entire net is a nightmare, from my viewpoint. You might get it to work, but I think the chances of its being done the same way repeatedly in a manufacturing situation are remote, and onboard the chances are probably non-existent. I think such panels are just too complicated to spend a lot of time considering, especially in hard bottom fisheries or any fishery that would be dealing with a lot of damage.

The cone arrangement seems to be the slickest thing among those separating techniques. One thing that I wonder about, even when they are presented by video, is that you generally see them towed perfectly square, with everything working fine. My experience causes me to wonder how that is going to get screwed up. What happens if the net isn't being towed square? This possibly happens more often than not. Do the fish still separate the same way? I don't think you'd find too many people who want to have giant escape vents in their trawls, whether or not they can do no harm if the thing is working properly. I wouldn't want to be interpreted as saying that I don't think that these are valuable ideas. It's just that I think there would be a fair amount of reluctance to implement some of these methods.

Something else that has been hit on is ensuring off-bottom performance of midwater trawls. Midwater trawls can certainly be towed midwater, but I haven't talked to anyone, about building a midwater trawl, who didn't insist that the thing be capable of being put on bottom, and with very valid reasons. Most of the species that would be targeted are interested in the bottom themselves, and that is where they are going to be caught. It's more effective to tow the style and net on bottom. I don't think it's too realistic to think that they are not going to be towed on bottom, and therefore, I don't think it's realistic for me as a manufacturer to make a midwater trawl that can't be put on bottom without serious harm occurring. It can be done either way with essentially the same net. I could build a trawl that will suffer severely as soon as it is put on bottom, or I could make that net, without imparing its midwater abilities, in such a way that it could be towed on bottom. I'd feel kind of foolish to do it any way but the latter. I have to ensure that it can be put on bottom because I know it is going to happen, especially with that kind of gear. It is going to become my problem to keep the thing in operation, so I feel I'm helping myself by covering the inevitable.

One of the most important things that I don't see being fully discussed here is not the whole issue of doing things to the gear to make the gear selective, but selective use of a given type of gear. As a net maker, you get used to seeing people take two identical products and do completely different things with them. It can be a problem. If a fellow says he has a net that isn't working in some way or other, it's reassuring if you can site five other people whom he's fishing against who work well with the very same net. The point I'm making is that there is a lot more involved than just specifying how the nets are made. In fact, the specifications of the net design are minor compared to its eventual use.

Another issue related to this, again from my standpoint, is that I have to be concerned with selling a product. In my particular area of southern New England, there's traditionally been virtually no interest in selective gear, and that is because everyone is interested in participating in a lot of different fisheries at different times. If there was such a thing as a pure squid net, it would be viewed as a luxury because fishermen aren't going to be squiding all the time. They want a net that will catch squid at one time, scup at another time, flats at another time, is easy to maintain, and will last forever. That's all they want. That's why we tailor our efforts to make a compromise product that does a lot of those jobs. Perhaps it doesn't do any of those jobs as well as it could, but from my viewpoint, it's a sellable product.

What that suggests to me is that the best possible solution is not for everyone to research or to design gear and think of little schemes to ensure that something will or won't get caught. There has to be other incentives for the user not to catch what will harm a certain species. All of the methods that I've heard so far, although I'm not really commenting on the scallop issues and the drags because I'm not knowledgeable about them, would be relatively easy to get around, and the specified plans would be usurped and made meaningless. I think that is the way it will work, provided there is still an incentive for the user to have by-catches of immature fish in the process of making money producing another product. He will find a way around the mesh sizes, around the square mesh codends, or around anything that you can think of.

I think you have your work cut out for you in the enforcement of any of the things I have heard about so far. It occurs to me, as a manufacturer of fishing gear, that in the event something does get regulated, for instance, a separator device for trawls, I assume that the specifications for the design will probably be less than completely specific. It will probably be approached from a standpoint of not allowing by-catch of such and such a species, and the manufacturer will be expected to have a device that regulates each particular catch. Who is liable if I manufacture this device, it is put in a trawl, and then the fellow who is fishing finds that the product doesn't work? Who is responsible there? Is it I? Can it be proven that I didn't manufacture that device properly? Is it the fisherman? This is an issue that I already deal with, not so much in terms of liability, but in terms of responsibility for anything I manufacture. I am responsible for the gear's working. If it can't be demonstrated that the net works, I don't feel I've had a made sale and I may have to take the product back. In the past, the way this has been approached is that I feel the burden is on me to know enough about what I'm doing to manufacture a product that is going to work.

Even though I manufacture a product that I'm convinced can work, I'm also convinced that it could be used improperly and that it cannot work under certain conditions. When I see this occur, I'm not ready to take back the product; I tell the guy to use it right. I think that should be the approach if I'm manufacturing a quality gear. I'd have the same approach to somebody telling me to install a separator device. If it were later decided that it didn't work, I'd have to know a lot more about it before I would accept responsibility.

I'd like to summarize by saying what I think really needs to be done. When you think about all the presentations so far and what you've seen, the only time I'm really convinced is when somebody shows a videotape of the actual underwater observation. I can look at graphs all day, but I constantly question how and by what means the data was collected. I don't have a lot of respect for it. I do have a lot of respect for the tapes that John Watson has used in developing the TED, seeing the behavior of the species. That is hard to argue with and I think if someone were to suggest that I was supposed to do something a certain way, I'd want to see that kind of evidence before I'd go along with it. I think that along those lines, money spent to support that kind of effort is well spent.

As a net maker, I have an equal, and sometimes greater, interest in the flume tank facility, which Cliff has been instrumental in making available to people such as myself. I'd like to see a lot more progress made in turning that into a facility more suitable to my work.

Another thing that troubles me, and I'm not sure why it happens so often, is that it seems a lot of the gear development goes on in situations where the expertise and the background of the people who are doing it is questionable. I think this stems from a lack of appreciation of how complicated the system is. Any given piece of gear that I design, or anyone else designs, is subject to a lot of variables. You're really expecting precise performance, and I suggest that you're not going to get it over the wide range of conditions that the gear has to perform in. I think it's a little presumptuous to make assumptions that this device, this mesh size, and this configuration will sort this way, and have any authority to do that without sufficient evidence to back it up. That is about all I have to say.

Question, Phil Averill: I think your points are well taken. I was glad that Cliff included this section in the program. Isn't it clear to say of the attitude of gear researchers that a project is not completed until there has been extensive field testing?

Paul Shuman: I'm not sure it's entirely a matter of their attitudes, but simply the way things get done. I view field testing of gear with some reservations also. It's one thing to offer to subsidize the use of a piece of gear, again, perhaps under ideal conditions. That's how I'd like to test something, too. But I have to manufacture a product to deal with the way these fishermen are going to abort this product and make it do all these horrible things that I hadn't intended it to do. That is real testing. That is actual use testing.

I'm presuming that somebody is going to have to manufacture all this stuff. Net making, good or bad, is still viewed as a cottage industry in this country, but I think that is on the way out. I think this point must be recognized. We are not just dealing with what somebody can do in a certain situation; we are dealing with manufacturing a product on a large scale. I'm not often consulted about how something could be manufactured; maybe a lot of these projects aren't really at the point where that is appropriate. I do wonder about the degree to which some of that would happen, and I base that question on the way the whole issue is treated in the press and in general. I think there is a lot of underestimating going on concerning what is involved and what is really necessary to accomplish some of these things. Even more important than that, though, is finding an incentive for the fishermen to concern themselves with the preservation of a species.

Comment, Kathy Dykstra: I think you are right, but I also think that there are some cases, such as ours in southern New England, where we have no incentive to take those small butterfish. It would be really helpful if we could find a way to not catch them. In that case there is already an incentive because fishermen don't want them aboard, it's a nuisance to have all those fish. So there is a case where if we could figure out a way to eliminate the babies, the incentive already exists.

Paul Shuman: Yes, that's true in that particular instance, but you can't divorce your opinion from the whole. I can't make a living selling nets only to people who want to preserve stocks. I'm asked to sell nets to the guy who wants to catch the small butters. Whiting is a better example. There will be times when, in our area, there are two approaches to whiting nets. One, is essentially a small mesh net and the other is a graduated net with a large-mesh front-end. In certain instances it's well documented that the small mesh net will catch more whiting than the graduated net. I think the point at which a fisherman switches from using a large mesh net to using a small mesh net varies quite a bit from individual to individual. There are people who, if they see anything gilled, will immediately switch to something smaller so they get it all. I'm not priviledged enough to be able to disregard that segment of net buyers and I don't think any net builder is. For me to get personally involved in something to lose small butterfish would mean I would have to have an economic incentive. A lot of the nets that my shop works on presently do address the issues somewhat. It's a different style of net than is traditionally used. They do catch a different size range of butterfish and I think that that happens because you are dealing with people who are targeting one thing. Again you have to get back to this issue: are you willing to use species selective nets? Most people aren't. People don't want to have five different nets for five different species.

An Inshore Draggerman's Viewpoint

Bentley Howard
F/V Jesse, Stuben

I work on a 58 ft. inshore dragger in the Gulf of Maine. I make trips of 2 to 3 days duration. I fish mostly groundfish, and do some shrimp fishing. I have been in the business for about 6 years, and I've taken net courses with Cliff, and took a course, somewhat like Cliff's, in Britain on net design .

The type of gear we've been using for a couple of years relates to one of the issues talked about here. We have been using a square mesh lengthening piece. The last year or so, we've been using a net with 8-inch mesh in the front and top and 6-inch throughout back to a 5-1/2 lengthening piece, which is on the square. We are using large-disk, lightweight-type sweeps. Some comments were made yesterday about the use of such sweeps on the West Coast to avoid by-catches of crab.

We are using some of the types of gear that have been talked about as management tools. First of all, from a practical point of view, I can live with square mesh, I can live with large mesh. There are problems with it, such as knots slipping, but they can be dealt with. They are no worse than any other problems we face. Second of all, my interests in getting into these methods, square mesh, large mesh, and different types of sweeps, have been economical: I'm trying to make more money. Conservation is secondary, except that it will benefit me economically down the line. There has been a lot of talk about conflict between some of these changes, like square mesh or large mesh, and economic incentives. My experience is that they can be linked, and the direction of research should focus on linking these incentives.

Square mesh lengthening pieces and codends reduce the amount of trash and small fish that you catch, but in terms of overall productivity, I don't feel they are a detriment. Different types of sweeps are also selective, but they can be selective in a positive, economical direction for a practical fisherman. So I think there is a lot of research that can be done on linking incentives. The positive changes in terms of management, with regard to larger meshes and square meshes, can also coincide with making more productive gear.

Another comment in relation to the type of gear we fish is that we made a lot of changes. We're not fishing typical gear in the area right now, but most of the boats are changing in terms of the types of nets and sweeps they fish. They are trying to fish harder bottom. They are getting away from a flatfish-type net, and they are going to high-rise type nets to catch groundfish, codfish, hake, and even haddock if they are around.

The point I'm trying to make is that we've dealt with a lot of change. The business is constantly changing and the changes proposed or talked about here in relation to management are not out of line with the type of changes that we impose on ourselves in order to make ourselves more productive. However, the changes we make are based on our opinion of what's going to be more productive, and again it gets back to linking incentives.

Another area of research that has been talked about a lot is square mesh versus diamond mesh and selectivity. My experience is strictly subjective and there may be differences in the distribution of sizes, but in terms of overall productivity, square mesh doesn't bother me at all. At times, perhaps, it is more productive. In terms of practical problems, you can deal with ways of hanging it and using gore ropes and so on that will keep it from stretching out. Certainly, more research can be done on selectivity, particularly on roundfish versus flatfish. We work in a mixed fishery and rely on many species to make our living, but as Paul Shuman pointed out, we tow basically the same type of gear, whether we're after flats or rounds, because we move back and forth over different types of bottoms within the same trip, even within the same day.

Another issue, or course, is mortality. If you're using a codend that allows a lot of smaller fish to escape, but you're killing a lot of them in the process, it certainly would be of interest. Fish behavior in relation to net is certainly dramatic, but there are differences in the productivity of the same net when used by different fishermen. That is something that Paul mentioned and it certainly has been my experience. Any sort of management tool that is based on design would have to be looked at in the context that, in the hands of different fishermen, it's going to behave very differently. Certainly, research in the direction of making a device bulletproof, that is, making it perform under a wide variety of conditions, is important.

Something as fundamental as a codend size is something that I can live with from a practical point of view. Again, one mesh on board is a policy I can live with. As far as a commercial fishermann is concerned, if somebody comes aboard and wants to measure my mesh size, he's welcome to do it. If he finds any other mesh size on board, then I'm breaking the law. It can be circumvented. I think the attitude in the area that I come from is changing. Fishermen see their catch rates have gone down dramatically in the last few years, and they know something needs to be done. I think they are interested in conservation measures. I think large mesh is something that people can live with because it's something easily understood. It's something easily dealt with on a day-to-day basis. But certainly there are areas for research in terms of selectivity.

I think some of this research can best be done by observing nets under working conditions. Again, from a practical point of view and to reiterate a point that Paul made, day-to-day use of a net that is stretched and torn and mended and so on can produce a very different situation from what you'll see in a test tank, or in an ideal situation as you have seen in some of the films that have been generated in Scotland. I think it's important to observe nets under working conditions and to observe these management tools under working conditions; and again, try and design systems that will stand up to that kind of use and abuse. I think underwater video is an excellent way to go. I'm not sure how else you'd do it. Certainly for monitoring fish behavior or getting some handle on mortality during escapement, I'm not sure how else you'd do it.

However, there is a paradox of sorts since some of the research on fish behavior and net design and so on leads to a potential for more productive and effective gear. In one sense, this compounds the problem of management. I think this is a paradox that shouldn't be removed from the situation. I think the fishermen who are willing to take the time and are willing to experiment and make use of research should be allowed the rewards from that. I think the conservation approach shouldn't hinder that, and certainly mesh size regulations wouldn't hinder that, but I think limited entry or lower catch limits would. So I'd be much more in favor of mesh size type regulations than I would be of limited entry or catch limits.

1986/87 Gear Research Plans

Phil Averill
Maine Department of Marine Resources

The Maine DMR is going to continue the video work at Swan's Island, where every three months we video the bottom of the dragged and undragged scallop areas. That project has worked pretty well and it will be continued. We are starting to get a few results out of that. After the next trip in about two weeks, we hope to have a summary tape of one year's results, almost like a time-lapse of one year of dragged and undragged bottom.

We will also continue working with the Undersea Research Program on the impact of scallop drags on juvenile lobsters and on the habitat. The first exercise was a couple of weeks ago in a series of trips aimed at observing this situation. That was a direct outgrowth of the *meeting* of this group in March in Boothbay.

As you have heard, we are about to start on a project working square mesh off commercial vessels. It will be a 4-5 month project. This is funded by the Maine Fishermen's Forum Inc. as part of the Fisheries Technology Institute. This is the first project of this group and it is 100% industry supported. So we are quite excited about that. We have already asked Bob Bruce of the Massachusetts DMF to serve on a technical advisory committee to help us with this and Bob has agreed to do as much as he is able. We've been talking to Bob Taber, and no doubt we'll be talking with Paul Shuman as the project progresses about construction of the square mesh and availability of suitable netting.

The mesh we will be using arrived the day before yesterday, and when I get back we'll be building up the extensions and fishing on Cy Lauriat's boat in a couple of weeks.

We've also received an S-K grant to continue the work on the separator trawl and get into a second phase of that work. The net does work, but it still has some design parameters that are more critical than I want them to be. We're going to be looking at these funnel separators to see if we can make that panel less critical, so that if a guy does tear up and mends it back crooked, it won't be the end of the world. We will be working on that, and when we get into the funnels and so on I'll be getting a hold of John Watson, Bill West, and others who have used these techniques to see if we can cooperate on that.

That is what we have planned immediately in addition to the usual activities that we, as an extension service, get involved in. What I'm planning on doing in the spring, once we get the separator trawl and the square mesh project done, is to seek funding for a lampara seine project for mackerel and squid. We have a lampara seine offered to us for free and we have the reels from a small project we did in Rhode Island two years ago with Dick Allen and Donnie Jones. We are hoping to come up with some additional funds to work on that. I'm excited about Ken Coons "what if" fund. I'm only looking for $5,000-$10,000 and this might fit into that because I already have close to $20,000 in kind match for that project. We're just looking for some operating funds. We were very excited about the results we got in Rhode Island, even though it didn't work. It wasn't the net's fault. We are thinking this might be a nice little mackerel fishery for small boats in Maine.

We also want to get back into cage drags for scallops and mussels as we discussed yesterday. We have the drag, it's just a matter of finding the time to tow it.

Another thing we are going to do in the spring is a ghost lobster trap clean-up. For those of you who haven't heard, a ghost-vent law goes into effect in Maine on March 1, 1987. It states that there must be a biodegradable element in the trap. Now that we have this law, it becomes feasible to clean up ghost traps. There are certain areas, usually at the mouths of harbors, that have a pretty high incidence of ghost traps. Before, it didn't make any sense to spend money cleaning them up. Now we are going to identify these areas and arrange for some volunteer divers from SCUBA clubs. Using our boat, we will go out and clean up these areas and, at the same time, document the number of lobsters in the ghost traps. We'll take the traps to a public landing where guys can pick through them and get their gear back. We are working on the insurance implications of the plan, as that seems the only thing I can think of that could mess us up. We are doing this in cooperation with the Island Institute in Rockland, which is a group that works with people who live on islands and tries to encourage island economies.

Another thing we may look into is ground fish traps. These are large lobster traps that catch ground fish and are used throughout the world. We've tried them in Maine a number of times, but they never worked well. There are some people who think they have designs that would work, so we'll be working with them to try to get a viable groundfish trap fishery going again for small boats. It will probably be used just to fill in between a couple of fisheries.

In conjunction with that, or on its own, we also want to look at FADs, fish attraction devices, something Tom Duym and I have been talking about for a long time. We envision the use of these in conjunction with the groundfish traps, or the lampara seine, or a jigging operation to attract the fish and concentrate them. FADs could be used for either pelagics or groundfish, depending on how you build them. For those of you who are unfamiliar with them, they are simply structures that you put in the water that attract fish because they provide shade or a break in the current. It is common down east to work in a 3 or 4 knot current. Behind big ledges you'll often find fish resting. Also, if you leave FADs out long enough they get fouling on them and the fish gather around these areas. They use them for tuna in Hawaii. So we want to look at their possible application in Maine. I think it might go hand-in-hand with the lampara seine if we can find a way to school up some mackerel behind the FAD.

Arnie Carr
Massachusetts Division of Marine Fisheries

The Massachusetts DMF hopes to be continuing our work on gill net impact. It has not been a subject here today but I'll briefly mention that there are several gill nets, which we've found, that are ghost gill nets located on Jeffries Ledge and Stellwagen or Middle Bank. We intend to look at these at different times of the year to try to assess the impact of these lost nets on groundfish. We've seen the net on Jeffries in June for the past three years, but we haven't really seen it at other times of the year to be able to accurately assess what these nets are doing.

Getting more into gear selectivity and management, Massachusetts has established three management initiatives. One is spawning area closures inshore, which principally relates to the winter flounder. Another is the codend mesh size of 5 inches and a gill net mesh size of 6 inches in these areas, when they are open to fishing, and in all other state waters north of Cape Cod. Also, there will be a minimum fish size for most species. We had to communicate with the fishermen about them. That is one of the roles of our extension agents: communicating prior to the inception of some of these regulations.

We are planning to work on the net selectivity of scup in Nantucket and Vineyard Sound areas. It is of extreme interest to us due to their abundance in early summer and midsummer. We will be working with Al Blott on this and he may have a few more things to say.

Another aspect of gear selectivity at which we will be looking relates to another crisis that has befallen Massachusetts. This is the gear conflict between the lobstermen and trawlermen. As in most other states, there has been a heavy increase of both activities. Following a series of hearings, both parties have made a tentative agreement to restrict night fishing in two areas where there is heavy conflict. These areas are in Boston and Cape Cod Bay. It hasn't been an easy task and I don't expect it will be easier in the future. The closure is in November or December when there is an extensive amount of gear in these areas. The gear is going to these areas, primarily because of the greater abundance of lobsters being found now in smooth towable bottom.

The lobstermen have been adamant about the trawling for lobsters that is going on in Massachusetts. They insist that trawling for lobsters cease and that this cessation be severely enforced. It is a gray area right now from a legal standpoint. Our intentions this fall were to start looking into trawling and resulting damage to lobsters by continuing the work in Connecticut, but applying it to the area of Plymouth/ Cape Cod Bay. We would look at the dragging of lobsters, the behavior of the lobsters with respect to the drag, and also the matter of injury and mortality associated with it.

Every spring and fall we have a resource assessment cruise throughout state waters that makes about 100 trawls during each cruise and assesses the relative abundance of each species caught. In this endeavor, especially in the fall, we have been assessing injury of lobsters. Certain areas have an abundance of lobsters and a relatively high injury rate; it is in these areas that we are going to look into monitoring the rate of injury and mortality. Our intention next fall is to collect more data by taking that same net, towing it in an area, and following it with video to get some empirical data on injury, not only in the net, but also in the path that the net has taken.

At this point in time, there is nothing more definite that I can report. However, I can see a great deal of effort in the future by Division personnel concerning gear selectivity as it relates to minimum size and mesh size. It is not a task that we are taking lightly; it is one for which we hope to be both conferring and working with industry. We hope whatever comes of it, rather than causing an adverse situation, will be something that most of the fishermen can use,.

Ken Coons
New England Fisheries Development Foundation

As usually happens in any meeting, there are several topics being discussed at once, even though Cliff brought us together to discuss gear selectivity. As Kathy Dykstra and Frank Mirachi said yesterday and as we saw in the scallop situation that Phil Cahill described, as of now we don't seem to be willing to regulate ourselves as an industry. In that context, selective gear, if it's really used, could reduce the habitat destruction and the ruinous discards which a) threaten the resource that is the fishermen's livelihood and b) play into the hands of those who would regulate fishermen, so that we have fishermen selectivity instead of gear selectivity. That is why I feel this conference is so timely.

A second topic to be discussed this afternoon is the lining up of additional funding sources for gear work. Gear work is obviously the passion of most of you in this room. I'm sure you also know that most of the people in the seafood industry really aren't very interested.

There is a large gap in communication, and it's easy for me and you and the organizations that we represent to delude ourselves into thinking that we are really in touch with fishermen, processors, distributors, and end users of seafood just because we have a handful of cronies who tell us we're doing great stuff. But believe me, we are not understood, and if we are not recognized and understood, we are not supported.

That brings me to the third item, the Foundation's agenda. Imperfect as we are as an organization, we are the only organization in the region that brings together fishermen, dealers, importers, processors and end users of seafood. We are not gear experts, we don't pretend to be, and we don't want to be. We have played a behind-the-scenes role in the four year project to encourage boxing and bleeding of fish.

We assisted in the acquisition of the Scanmar gear and the square mesh trials in Massachusetts. We supported the

Maine Ground Fish Association's quality program, and we played a key role in getting the gear required by Rich McLellan for his pair trawl experiments. We also assisted in getting him over to Aberdeen and getting those researchers over here. We put a new deck handling system on another Maine vessel that is demonstrating how to take the work out of boxing on board.

We have been asked in the coming year by the National Marine Fisheries Service to assume the lead role in coordinating the Conservation Engineering Project. Frankly, it's a role that we undertook with a great deal of trepidation. In fact, I consulted with a number of the Foundation's organizations of fishermen to ask them if they thought we should accept the project. The overwhelming feeling was that we should accept, because if we didn't, they wouldn't have industry input and something would more than likely be developed that would be rammed down their throats, whether they approved of it or not.

So the work plan looks like this. We will convene an advisory board that will probably be very similar to the existing advisory board. It will include Phil Averill and Cliff Goudey and the very worthwhile work that they're doing on S-K projects. We will do this with the closest possible partnership of the regional councils. We've already had one meeting with Doug Marshall and Guy Marchesseault on this subject. The states will be represented and we'll do our very best to involve fishing industry leaders. In fact, that is the whole point of our involvement.

In addition to coordinating the progress of Phil's and Cliff's S-K projects, we'll also be responsible for the scallop gear project. We will be responsible for reporting on them on a quarterly basis. One of the most interesting parts of this project, as an advisory group, is that we'll also have the opportunity to develop a 5-year plan for gear testing. Our intention is to broaden the scope of this 5-year plan to make recommendations for regional fishery management. We'll only be sucessful if we're able to involve the industry affected, and our plan has got to be their plan if it's going to work.

At the end of the year, the advisory group will see how the Foundation has done in this role. If we have been ineffectual and only a bothersome layer, we'll go on to other things. We will self-destruct as far as this work is concerned. We are deeply involved in seafood education programs. We are running three fish schools. We are in the middle of a very exciting three year program to develop valuable by-products from fish waste.

I'm well aware that some of you see yourselves as a closed group of kindred spirits, and you obviously resent the intrusion of the Foundation. I honestly believe that we can bring an important new dimension to your work by helping to bridge the communication gap, which I believe really exists.

Lastly, I would like to throw out an idea that I hope you will support. Several of you have mentioned the need for a discretionary "what if" fund. Often, all that is needed is a few thousand dollars to try out a good idea or to hook up a fishermen with a new market. Both the S-K and the Sea Grant processes are much too cumbersome, and they don't allow for a contingency fund. So what I propose is that we set up our own. I recently attended the Trashfish Banquet in Provincetown and it made me think, "What if we put together a series of these in New England and put the proceeds into a 'what if' fund to be administered by a Board of Fishermen and one or two dealers?" If we had $30,000 to $40,000 accumulated in this kind of discretionary fund, we could fund the good ideas that need a faster response time than our present system is able to provide.

The Foundation intends to organize these, at least initially, and we don't plan to take any overhead cut from our efforts. So it would all be passed through to go into this "what if" fund administered by a Board of Fishermen, a few dealers, and whoever else you think ought to be a part of it. I think it will work and I hope you support it. I'm looking forward to working with you.

Cliff Goudey
MIT Center for Fisheries Engineering Research

A major project we are working on, the development of the towed observation vehicle, will be instrumental in a lot of the activities that have been mentioned today. There is a range of projects for which we hope to see the vehicle used. An advisory committee will help me in refining the objectives of the vehicle, and in setting up the proper mechanisms by which it will be used by the industry and research organizations.

The time frame for that project and the availability of that system should not alter much from what was in the original proposal. Again, because we are talking about procurement of already proven hardware, I don't anticipate major delays. Because the system will be fundamentally simple, we should be in a position to be operational by this summer. The advisory committee will help in prioritizing and scheduling so that everyone gets a fair shake at using it. There will be a period when we'll be doing operator training because, as simple as it is, it is still going to be a valuable piece of hardware and safe operation will be critical. That activity will take place once it becomes operational.

A second project relates to something that Bill West mentioned was a very high priority item on the West Coast. The problem is the mortality and by-catch of crab in the yellowfin sole fishery. It seems the industry has developed gear which solves the problem, but the mechanism for that solution and its demonstration to fishermen are tasks that remain. Through the use of scale models, we hope to learn about the dynamics of that gear. Whereas most of our work has been in the circulating channel, this work will be the first major use of the NSRDC tow tank facility. The 52' wide NSRDC tow tank is a very unique facility with some amazing potential to model the entire trawl system at reliable scale ratios.

For the coming season, I have a schedule of trawl courses set up. This is our third season and we are now getting into more specialized courses for a particular part of the country. Gear varies so much from one region to another that if you have a group of fishermen from all across the country, even though the interactions are often quite beneficial, it can be frustrating if there's not a chance to spend much time with each gear. For the first time, we will be holding a course specifically for shrimp fishermen. I think this is going to be an interesting season.

In the circulating channel, we've long needed an efficient system for determining the geometry of trawl models. It can become time consuming if you want to get the detail shape of a net. Headrope height, wingend height, and wing spread are three measurements that are fairly easy to get, but by no means does that describe the geometry of the net. We're not blessed with a whole wall of windows, and to get a picture of the whole net requires a very wide angle lens which produces a great deal of distortion. In order to solve that problem, we're going to develop a system by which we direct two laser beams to a point on the net, and by measuring the pan and tilt angles of the beams, we'll be able to determine the x, y, and z coordinates of that point. This will provide us with a very unique capability compared to the other test tanks.

With this system, subtle changes in the design of a net can be measured. Those changes are difficult to document since you can't necessarily stick a yardstick in all places of interest to get a vertical measurement. To be able to quantify the rate at which nets taper is very important. If you know the geometry of the body of the net and you know the mesh count circumference, you can determine the bar angle and, therefore, the mesh openings in that area.

That problem comes up again and again. Net is such a flexible thing that it may perform a certain way under certain circumstances, but change drastically with a large catch or some other disturbances. We can simulate those kinds of physical forces in the tank, but we need a way to measure and quantify the effect.

Something that may seem a bit unrelated is roll motions of fishing vessels. However, I believe it has an impact on the effectiveness of gear since anything that you can do to reduce the motions of the boat is going to make gear perform that much more consistently. We're going to look at things like bilge keels, flopper stopper paravanes, and also at some more innovative methods of reducing roll to compare how they work. We will be model testing in the MIT tow tank right here on campus.

A final thing that is presently in the proposal stage, but I hope will be funded, is a two year effort. It's a spinoff from some Sea Grant work that was done a number of years ago in the Ocean Engineering Department on the prediction of the geometric shape of mooring cables. The same physics are involved in geometry of any kind of a cable in a stream and under certain end conditions.

We've adapted these computer techniques for the Navy to analyze the geometry of mine sweeping nets. It was instructive to me but it's not clear yet how accurate the process is because we're plugging in estimated coefficients of friction and drag. So part of this project is going to be quantifying some of these forces. For example, what's the difference between dragging a bare wire and 3 inch cookies along the bottom? We will also study how that relates to the type of bottom. All of those things are going to be required if you're going to have a useful model.

Consider how handy such a computer model would have been in Richard McClellan's process of trying to find out what his boat spacing should be for certain configurations of net and warps.

It would be useful from the standpoint of fisheries management to know what the level of fishing is within a current fishery and what is going to be the impact of increasing that effort. What would be the impact of introducing a 800 HP vessel instead of 300 HP vessels; does that double or triple the fishing power? The model we propose will include the vessel characteristics and be able to relate things such as horsepower or propeller diameter to bollard pull and the swept width of the gear. A lot more has got to be learned before we can do that and part of that is going to be included in the second year and will be based on results from the gear observation system.

Al Blott
NMFS Narragansett Laboratory

The NMFS Fisheries Engineering Group will be getting back into scallop work in several ways. One is by working with Ron Smolowitz on the ring size tests that he is doing on commercial boats. We are also going to be looking at the cage for a scallop drag. This winter we're going to compare that with an 8 foot commercial drag. We are also working with some ideas on how to take commercial gear and change the chafing gear so that it holds the bag up off the bottom. There are two or three different variations that we are going to be looking at. We'll probably be doing some of this on the *Gloria Michelle*, and I hope we'll be able to get into some of the offshore areas with the *Albatross*.

A third part of our scallop work has a more academic approach. We have a student who is looking into sorting techniques without being prejudiced by the existing gear. It may go nowhere, but seeing that we have the use of a fresh mind, we didn't want to burden him with looking at the existing gear first and then trying to come up with some kind of a selectivity technique. It may be quite interesting if we can come up with something that would select scallops in a new way.

Another project is working with the Massachusetts DMF on the selectivity of scup trawls and scup behavior. We hope to use the new video system, or if that is not available, we'll go back to the old towed sled and hand-held TV camera techniques. We're just into the planning stage of that. What

I would like to do beyond that is to use the new observation system to look at butterfish gear. However, that is something well down the line.

The third area is a couple of studies we hope to do with URI. We have a memorandum of understanding with the University of Rhode Island, and we work very closely with their fisheries people and the Ocean Engineering Department.

Joe DeAlteris
University of Rhode Island

I am interested in the selectivity of fishing gear, in particular the performance and catchability of scientific sampling trawls. I have experience in the Mid-Atlantic region as a fisherman, research scientist, and charter research vessel operator. In this capacity, I observed and compared the catches of commercial trawls and scientific sampling trawls. Needless to say, the commercial trawls produced considerably greater catches; the scientific sampling trawls did not yield representative catches in terms of species diversity and size distribution. Because of the smaller mesh size, smaller fish were retained. However, the larger fish were not captured.

The research project at the University of Rhode Island incorporated these observations to evaluate the performance and catchability of scientific sampling trawls. The standard scientific sampling trawl used in the Mid-Atlantic region is a 40 foot sweep, 4-seam shrimp trawl made with a 1-1/2 inch stretch-mesh webbing. It is towed from a single warp with a bridle to flat doors. The bridle length ranges from 50 to 150 feet. The performance of this net with various rigging arrangements was compared to a scientific sampling trawl designed and built at URI. This net is a 2-seam, 40 foot sweep, v-wing, high-rise trawl, with a constant 3B/1P taper. The webbing is 3 inch stretch mesh in the net mouth, reducing to 1-1/2 inch stretch mesh in the bellies and extensions.

Trawl geometric performance was evaluated with a SCAN-MAR system that was calibrated to 0.5 feet. The experimental design included measuring the trawl mouth geometric performance and analyzing the catch data for both nets at various towing speed and rigging configurations. The shrimp trawl was towed with 50, 100 and 150 foot bridles to a single warp, and with two warps. The URI net was towed with V-doors and 60 foot legs.

With respect to geometric performance, the results are most interesting. On the shrimp trawl, a 50 foot bridle produced a 16.4 foot horizontal net mouth opening; the 100 foot bridge allowed a 20.0 foot net mouth opening; and the two warp arrangement yielded a 23.0 foot net mouth opening. The URI net only had a 14 foot horizontal mouth opening, but because of the 60 foot legs, the spread between the doors was 30.0 feet, yielding an 11 degree bridle angle.

At this time, over 150 tows of 15 minutes in duration have been made. We are statistically analyzing the data on wing spread, door spread, height opening, catch amount and catch composition. It will be interesting to compare the tow to tow variability in catch with variability associated with gear design and rigging.

Several other projects related to gear performance and selectivity are in the preliminary stages at the University of Rhode Island. We are developing a Fishing Vessel Energy Efficiency Evaluation System. The system will include the following components:

1) An engine performance and fuel consumption monitor consisting of these sensors:
    a. fuel flow intake
    b. fuel flow return
    c. engine RPMs
    d. exhaust temperature.

2) The vessel performance component includes the following sensors:
    a. speed through the water from an impellor log
    b. speed across the bottom from Loran C
    c. warp tension meters that measure the total load of the fishing gear on the towing vessel.

3) The fishing gear performance sensors include the following:
    a. door spread
    b. wing spread
    c. height opening

The combination of these sensors will permit the determination of the area of the net mouth opening and the effective fishing area between the trawl doors. The outputs of these instruments are digital and can be processed directly. This system, manufactured by SCAN-MAR in Norway, is the key element of the project. It is expensive, but very rugged and functional.

A portable microcomputer will be used to sample the various sensors and instruments at specified intervals, taking averages over prescribed time periods, then storing the data on disk and displaying the data on screen in real-time format in the pilot house of the fishing vessel. It is planned to offer this system to the fishing industry as a Marine Advisory/Cooperative Extension Service activity to assist fishermen in the evaluation of fishing gear performance.

It is anticipated that after development and testing of the system, a technician could install the equipment on the client fishing vessel in one to two hours, then proceed to an adjacent fishing ground for a specific sequence of trial runs at different engine settings, with and against the tide, and finally with different fishing gear configurations. The variables in this later category are numerous and include net size and design, door size and design, length of legs and ground gear, flotation, etc. The length of the experimental period on board a particular vessel may vary from one to three days, depending on problems and the variety of gear to be evaluated.

A second project being initiated is the study of the effect of mesh size and twine diameter on the filtration performance of scientific sampling trawls. The objective of this study is to investigate the effect of mesh size and twine diameter on the flow distribution within and around estuarine scientific sampling trawls, so as to evaluate the relationship between these parameters and filtration performance. Personal observations and preliminary data from an ongoing project indicate that filtration performance significantly affects the catchability of scientific sampling trawls. It is hypothesized that a reduction in the filtration performance results in an acceleration front in the net mouth, which affects a dynamic pressure gradient ahead of the net. These phenomena trigger an avoidance reaction by target fish.

It is planned to conduct the proposed project, in cooperation with MIT, at the circulating water channel at NSRDC in Maryland, using a laboratory quality electromagnetic current meter and dye injection to measure the flow distribution within and around the net. A single net design will be used with panels made up of a variety of mesh sizes and twine diameters. In addition, the effect of small mesh liners will be evaluated. A total of 24 net configurations, based on 8 nets with 3 different liners, will be tested . The resulting contour maps of flow distribution in the net mouth will be used to calculate the filtration efficiency for each net. These will be related to net design, simulated towing speed, and net drag.

The results of this project will enhance our understanding of the hydrodynamics of net performance so that an improved sampling device can be designed. In addition, the results will be useful in the rationale design of more selective towed fishing gears, including separator trawls and other sophisticated net designs.

Gear Selectivity as a Management Tool
14-15 October 1986
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